VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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Project Report on

"Food Spoiling Detection Using IoT"

Submitted in Partial fulfillment of
BACHELOR OF ENGINEERING DEGREE
IN
ELECTRONICS & COMMUNICATION ENGINEERING

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING
TONTADARYA COLLEGE OF ENGINEERING
MUNDARGI ROAD, GADAG-582 101

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S.T.S.K. K's

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

CERTIFICATE

Certified that, the Project Work entitled ***"Food Spoiling Detection Using IoT"*** *carried out by Ms.* ***Preeti Hombalmath(2TG21EC041),****Ms.****Shobha Goudar(2TG21EC048) and*** *Ms.****Tulasi Valluru(2TG21EC059)*** *the bonafide students of Tontadarya College of Engineering, Gadag, submitted the report, in partial fulfillment for the award of Bachelor of Engineering Degree in Electronics & Communication Engineering of the Visvesvaraya Technological University, Belagavi during the year 2024-25.*

It is also certified that all corrections/ suggestions indicated for Internal Assessment have been incorporated in the report and deposited in the department library. The report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said Degree.

Signature of the Guide	**Signature of HoD**	**Signature of Principal**
Prof. Mahant K. M.Tech. Assistant Professor ECE Dept., TCE Gadag	Prof.Jagadeeshwar G Shivanagutti B.E, M.Tech. HoD ECE Dept., TCE Gadag	Dr. M. M. Awati M.Tech, Ph.D Principal TCE Gadag

External Viva: Name of the examiners Signature with date	1.	2.

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Declaration

We, bonafide students of the Department of Electronics & Communication Engineering at Tontadarya College of Engineering, Gadag, hereby declare that the Project Work Course entitled "Food Spoiling Detection Using IoT" has been carried out by us, under the supervision and guidance of the Department Staff Supervisor and submitted the report, towards the partial fulfillment for the award of Bachelor of Engineering Degree in Electronics & Communication Engineering of the Visvesvaraya Technological University, Belagavi during the year 2024-25.

We also declare that the work has not been submitted previously for the award of any other degree or diploma, by the Institute.

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ABSTRACT

Food spoilage is a significant issue in the food industry and households, leading to health hazards and economic losses. This project presents an IoT-based system for detecting food spoilage using a DHT11 sensor, a gas sensor, NodeMCU ESP8266, and an LCD for real-time monitoring. The system aims to ensure food safety by alerting users about potential spoilage conditions. By leveraging IoT technology, the system provides timely alerts and enables prompt action. Real-time monitoring allows users to track food conditions and take necessary measures. The system's effectiveness in detecting spoilage makes it a valuable tool for food safety management. It offers a practical solution for households, food industries, and storage facilities. The system's benefits include reduced food waste, economic savings, and improved food quality. With its user-friendly interface and real-time updates, users can easily monitor food conditions. The system is designed to be efficient, reliable, and cost-effective. By integrating sensors and IoT technology, the system provides accurate and timely spoilage detection. This project demonstrates the potential of IoT in enhancing food safety and reducing spoilage-related losses. Overall, the system presents a promising solution for ensuring food safety and quality. It enables users to take proactive measures against spoilage, reducing health risks and economic losses. The system's real-time monitoring capabilities make it an effective tool for food safety management. By adopting this system, users can ensure safer food storage and handling practices.

ACKNOWLEDGEMENT

The satisfaction of successful completion of any task would be incomplete without the expression of gratitude to the people who have made it possible. We acknowledge all the people who have guided and encouraged me/ us.

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LIST OF ABBREVIATIONS

IOT	Internet of Things
NodeMCU	Node Microcontroller Unit
ESP	Espressif Systems
DHT	Digital Humidity and Temperature
LCD	Liquid Crystal Display
LED	Light Emmiting Diode
Arduino IDE	Arduino Integrated Development Environment
RPS Unit	Regulated Power Supply Unit
CNG	Compressed Natural Gas

CHAPTER – 1

INTRODUCTION

1.1 Background

Food spoilage is a significant concern globally, resulting in substantial economic losses and health hazards. According to the United Nations Food and Agriculture Organization (FAO), one-third of all food produced worldwide is lost or wasted. In addition to the economic impact, food spoilage can also lead to foodborne illnesses, which affect millions of people worldwide each year.

To address this issue, this project proposes an innovative solution using Internet of Things (IoT) technology. The system, titled "Food Spoiling Detection Using IoT," aims to detect food spoilage in real-time, enabling prompt action to prevent health risks and economic losses.

By leveraging sensors, microcontrollers, and IoT platforms, this project develops a low-cost, scalable, and user-friendly system for monitoring food storage conditions. The system tracks temperature, humidity, and gas emissions, providing real-time alerts and notifications when spoilage conditions are detected.

It is mandatory to grow a system that can assist people to identify the elegance of food or quality of food items. The quality of the food should checked to prevent it from spoiling under different environment conditions like temperature, humidity, vegetable/fruit characteristics , which will be helpful to check quality through different techniques.

The sensor senses the food quality through change in its colour. There are various signal processing and pattern recognition techniques to detect food intake time through sensors.

This project has far-reaching implications for various stakeholders, including households, food storage facilities, and the food industry as a whole. By reducing food waste and preventing foodborne illnesses, this project contributes to a safer, more sustainable, and more efficient food supply chain.

1.2 About IoT

The Internet of Things (IoT) connects devices, sensors, and objects to the internet, enabling real-time data collection, monitoring, and analysis. It applies to various domains, including smart homes, cities, and industries, improving efficiency, productivity, and decision-making. IoT enhances automation, safety, and convenience, with examples including smart thermostats, wearables, and industrial sensors. These devices communicate with each other and the cloud, driving insights and actions through data analytics and machine learning. As a result, IoT transforms industries and daily life, with its applications continuing to grow and evolve rapidly. Overall, IoT is revolutionizing the way we live and work. Its impact is profound.

1.3 Problem Formulation

- Food spoilage causes health hazards and economic losses.
- Current detection methods are manual and inefficient.

1.4 Objectives

- Identify early signs of food spoilage to prevent health risks.
- Provide real-time alerts through an IoT-enabled platform.
- Enable local and remote monitoring via LCD and mobile apps/web dashboards.

1.5 Expected Outcomes

- Accurate display of temperature, humidity, and gas levels on the LCD.
- Real-time updates accessible via IoT platform dashboards.
- Immediate notifications (via app/email) upon detecting unsafe conditions.
- Users can respond promptly to preserve food and avoid spoilage.

1.6 Motivation

The motivation behind this project is to address the pressing issue of food spoilage, which affects not only households but also the food industry as a whole. Food spoilage can lead to significant economic losses, health hazards, and environmental impacts. Current methods for detecting spoilage are often manual, inefficient, and unreliable, highlighting the need for a more effective and efficient solution. By leveraging IoT technology, this project aims to develop a system that can detect food spoilage in real-time, enabling prompt action to be taken and reducing the risks associated with spoiled food.

The potential impact of this project is substantial, with benefits extending to both consumers and the food industry. By ensuring food safety and quality, this project can help reduce foodborne illnesses, economic losses, and environmental waste. Additionally, the system's real-time monitoring capabilities can enable more efficient food storage and handling practices, leading to cost savings and improved productivity. Overall, this project has the potential to make a significant contribution to food safety and sustainability, and its development and implementation can have far-reaching benefits for individuals and society as a whole.

CHAPTER – 2

LITERATURE REVIEV

Food choice is like an all alternative human behavior is complicated and is affected by many interconnected factors. Understanding those factors associated with nursing is crucial, since it has created important factor for population dietary modification. Variety of models looking to point out the potential effects of such influences are planned within the survey.

One amongst these models tries to reason the factors those associated with the food (structural/biological properties, nutrient content), to the person creating the selection (perception of sensory attributes, psychological factors) or to the external economic and social setting at intervals that alternative is formed techniques to detect food freshness. The following sections will discuss each technique in detail.

[1] **Meat Freshness identification system using gas sensor Array and sensor in conjunction with neural network pattern Recognition**

In freshness level in the meat is important to determine the quality of meat.to overcome this problem the sensor system has been designed to check the freshness of the meat. The system consists of Raspberry PI connected with gas and colour sensors to match with the human vision to detect freshness of poultry product. Pattern recognition with neural network is used to identify the freshness of stuff. This will input the odour which can be identified by gas sensor with the array of MQ-136, MQ-137, and TGS-2620 sensor. The freshness is checked based on three levels like fresh meat, half-rotten meat and rotten meat. The usage of the sensors will help us in determining its distinct pattern. The identification of meat freshness will be with 80%.so that we can say stuff is fresh, the vary in pattern says its half -rotten and rotten meat. These two types are not consumable. Thus from this we can define has system is succeed in identifying or checking the freshness of poultry products.

[2] Freshness Evaluation of Three Kinds of Meats Based On Electronic Nose

In paper the study will define the use of electronic setup to predict or detect the freshness of the poultry products like pork, beef, mutton, etc. The freshness is measured in three levels. They are fresh, sub fresh and putrid. By sensory evaluation, and with the help of electronic device, we discriminant factor analysis. The component analysis shows the electronic device could identify the samples with different storage. There are three types of meat sample chosen and stored for seven days. The discriminant factor shows the electronic device could differentiate and able to identify the freshness of the food item. If the freshness value lays fewer than 89.5%, 84.2%, 94.7% for pork, beef and mutton then we can say that the sample is fresh.

[3] Detection of Freshness of Fruits Using Electrical Method

In paper moisture content of the fruit is an important quality factor to detect the freshness of the fruit. Technique content of fruits has effective influence on the density of fruit. Electrical methodology is employed to notice the freshness of fruit. This work will estimate the freshness of the variety of fruits with the electrical based approach. Checking the wet content of fruits is clear higher the wet contents within the fruit offers higher within the quality of fruit. Wet content of all form of fruit has 80-95% of its whole weight. This means that fruit is contemporary if larger wet content in larger amount. Additionally, wet loss throughout days causes loss in its weight. Electrical technique is easier than that of normal technique to notice the freshness of fruits.

[4] Fruit Freshness Detection Using RASPBERRY PI

This paper sheds light on the advancements made in the agricultural industry. Digital image processing techniques are now widely used for the maturity estimation of fruits. This work aimed to study and analyze the various algorithms and feature extraction techniques that are now used for the extracting features from the captured digital images. Thus, it is important for the suppliers to label the quality of fruits. In this paper, we are inspecting the quality of fruits based on size, shape and color and also by its weight. All of these algorithms are implemented using RASPBERRY PI development board which will become an independent and cost effective system. All the interfacing of the components will be carried out and it will make a cost effective embedded system prototype for the determination of size, shape and color of the fruit. Same system can be utilized for other fruits conjointly.

Advantages and disadvantages of various classifiers have been classified. It was observed that for achieving high accuracy a compromise had to be made with high computational complexity.

[5] IoT Based Milk Monitoring System for Detection of Milk Adulteration

Sustenance security in provincial and concrete zones is a particularly vast, because it nearly influences the soundness of nationals. In paper late examinations find that crude milk contains horrific life forms that might induce contamination if eaten up which might build the speed of infections and break down the non-public satisfaction. Thus, creating apparatuses for constant and shrewd detection is needed for quality checking and to decide on affordable and opportune alternative. The work aimed to present some aspects concerning milk quality and amount estimation. The web of Things (IoT) primarily based system permits users to understand the groupings of gases in crude milk incessantly. Because of the milk is unbroken for many days, the enlargement of bacterium can get enlarged that bacteria in undesirable smell, vogue and harmful substances. Hence, there's a necessity for observation system to get and confirm the spoilage of milk and switch out into a healthy product. Consequently, the toxic substances in milk area unit known before to take care of a strategic distance from entanglements within the underlying stage for a good last item. In this projected system, microorganism activity is set victimization gas detector, high quality milk ought to do not have any salinity, conjointly salinity of the milk is measured by employing a salinity detector and also level of the milk are going to be measured by employing a level detector. Additionally, should have their card for accessing the milk diaries.

[6] IOT Based Detection of Microbial Activities in Raw Milk

In our day today life the food freshness is decreasing due to adulterating the food stuff by mixing low quality adulterant for original food stuffs. This will leads to several health issues when human beings consumes this food. It has been affected in rural and urban areas. Many of the results have been show that the stored milk contains some amount of microbes like bacteria. From this we understood that there is a need to develop some monitoring or controlling system to keep tracking or checking the freshness of the raw milk. In the paper there are sensor unit which has to be connected to Arduino Uno board and all the inputs are given to application with the help of Bluetooth module. Based on fat and liters the amount of microbial activity is calculated. From the mobile application the result update is given to users.

CHAPTER – 3

PROPOSED WORK

The proposed work aims to design and develop an IoT-based food spoilage detection system that can monitor food quality in real-time. The system will utilize sensors to track temperature, humidity, and gas emissions, which are indicative of food spoilage. The main objectives of the proposed work are:

- To design and develop a low-cost, scalable, and user-friendly food spoilage detection system
- To integrate sensors and IoT technology to monitor food quality in real-time
- To develop an algorithm to analyze sensor data and detect spoilage patterns
- To implement a notification system to alert users of potential spoilage

CHAPTER – 4

REQUIREMENTS

The design and development of this project requires hardware and software tools as listed below.

Hardware requirements:

- NodeMCU ESP8266
- DHT11 Sensor
- Gas Sensor (MQ4)
- 16x2 LCD Display
- I2C LCD Module (optional)
- Resistors
- Breadboard
- Connecting Wires
- Power Supply
- Buzzer/LED (optional)

Software Requirement:

- Arduino IDE
- ESP8266 Board Package
- IoT Platform
- LCD Library
- DHT Library
- MQ Gas Sensor Code
- Wi-Fi Configuration Code

Additional Tools

1. IoT Monitoring Platform
    - ThingSpeak
    - Firebase
    - Blynk App
2. Mobile/Desktop Device

3. Multimeter

More details about these requirements are discussed here.

4.1 Node MCU-ESP8266:

NodeMCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.

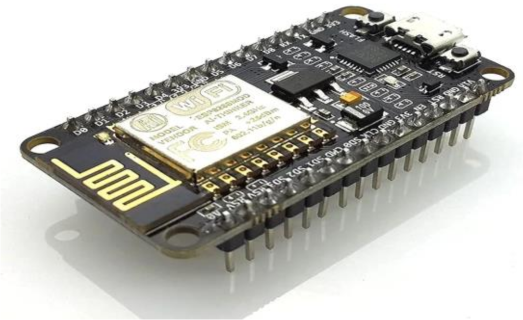

Fig 4.1 Node MCU- ESP8266 Board

- **Features of Node MCU-ESP8266 Microcontroller**

1. **Memory:**

- Microcontroller ESP-8266 32bit
- NodeMCU Model- Amica
- ADC Range 0-3.3 v
- 4 MB Flash
- 64 KB SRAM
- Temperature Range -45C to 125C
- WiFi Built-In-802.11 b/g/n
- UART/SPI/12C-1/1/1
- Operating Voltage-3.3 v
- USB Connector-Micro USB
- Clock Speed-80MHz
- Pin Spacing-0.9”(22.86mm)
- Input Voltage-4.5 to 10v

2. **Peripherals:**

- Power Pins: There are four power pins. VIN pin and three 3.3V pins. VIN can be used to directly supply the NodeMCU/ESP8266 and its peripherals. Power delivered on VIN is regulated through the onboard regulator on the NodeMCU module – you can also supply 5V regulated to the VIN pin 3.3V pins are the output of the onboard voltage regulator and can be used to supply power to external components.
- GND :are the ground pins of NodeMCU/ESP8266
- I2C Pins: are used to connect I2C sensors and peripherals. Both I2C Master and I2C Slave are supported. I2C interface functionality can be realized programmatically, and the clock frequency is 100 kHz at a maximum. It should be noted that I2C clock frequency should be higher than the slowest clock frequency of the slave device.
- GPIO Pins: NodeMCU/ESP8266 has 17 GPIO pins which can be assigned to functions such as I2C, I2S, UART, PWM, IR Remote Control, LED Light and Button programmatically. Each digital enabled GPIO can be configured to internal pull-up or pull-down, or set to high impedance. When configured as an input, it can also be set to edge-trigger or level-trigger to generate CPU interrupts.
- ADC Channel: The NodeMCU is embedded with a 10-bit precision SAR ADC. The two functions can be implemented using ADC. Testing power supply voltage of VDD3P3 pin and testing input voltage of TOUT pin. However, they cannot be implemented at the same time.
- UART Pins: NodeMCU/ESP8266 has 2 UART interfaces (UART0 and UART1) which provide asynchronous communication (RS232 and RS485), and can communicate at up to 4.5 Mbps. UART0 (TXD0, RXD0, RST0 & CTS0 pins) can be used for communication. However, UART1 (TXD1 pin) features only data transmit signal so, it is usually used for printing log.
- SPI Pins: NodeMCU/ESP8266 features two SPIs (SPI and HSPI) in slave and master modes. These SPIs also support the following general-purpose SPI features:

  4 timing modes of the SPI format transfer

  Up to 80 MHz and the divided clocks of 80 MHz

Up to 64-Byte FIFO

- SDIO Pins: NodeMCU/ESP8266 features Secure Digital Input/Output Interface (SDIO) which is used to directly interface SD cards. 4-bit 25 MHz SDIO v1.1 and 4-bit 50 MHz SDIO v2.0 are supported.
- PWM Pins :The board has 4 channels of Pulse Width Modulation (PWM). The PWM output can be implemented programmatically and used for driving digital motors and LEDs. PWM frequency range is adjustable from 1000 µs to 10000 µs (100 Hz and 1 kHz).
- Control Pins: are used to control the NodeMCU/ESP8266. These pins include Chip Enable pin (EN), Reset pin (RST) and WAKE pin.
- EN: The ESP8266 chip is enabled when EN pin is pulled HIGH. When pulled LOW the chip works at minimum power.
- RST: RST pin is used to reset the ESP8266 chip.
- WAKE: Wake pin is used to wake the chip from deep-sleep.

4.2 Board Topology:

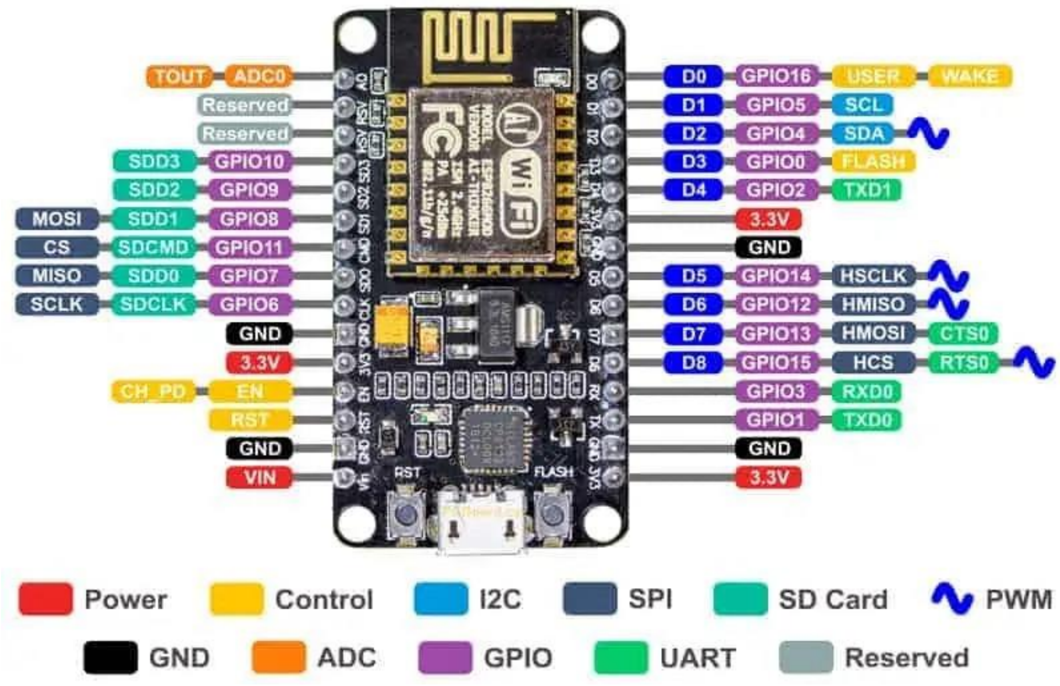

Fig 4.2 Board Topology

Table 4.1 Pinouts of Board

Pin Type	Pin Name	Pin Description
Power	Micro-USB, 3.3V, Vin, GND	**Micro-USB:** It can power the NodeMCU. **3.3V:** A regulated 3.3V supply can also power the NodeMCU. **Vin:** External power supply pin **GND:** Ground pins
Control pins	**EN, RST**	The button and pin can reset the microcontroller.
Analog pins	A0	It measures analog voltage within the range of 0-3.3v.
GPIO pins	GPIO1 to GPIO16	There are sixteen general-purpose input-output pins on the NodeMCU board.
SPI pins	SD1, CMD, SD0, CLK	There are four pins that work for SPI communication on NodeMCU.
UART pins	TXD0, RXD0, TXD2, RXD2	NodeMCU features two UART interfaces including UART0 (RXDO and TXD0) and UART1 (RXD1 and TXD1). You can use UART1 to upload programs or firmware
I2C pins.		You can get I2C functionality support on NodeMCU. However, you have to find the I2C pin because of these pins' internal functionality.

- **Processor:**

The ESP8266EX microcontroller integrates a Tensilica L106 32-bit RISC processor, which achieves extra-low power consumption and reaches a maximum clock speed of 160 MHz. The Real-Time Operating System (RTOS) and Wi-Fi stack allow about 80% of the processing power to be available for user application programming and development.

4.3 DHT11 Sensor:

The DHT11 sensor is a widely used, low-cost temperature and humidity sensor that has become a staple in various applications, including weather stations, home automation systems, and industrial automation. With its simple interface and compact design, the DHT11 sensor offers a convenient and affordable solution for measuring temperature and humidity levels. This project/report aims to explore the features, applications, and limitations of the DHT11 sensor, as well as its potential uses in real-world scenarios.

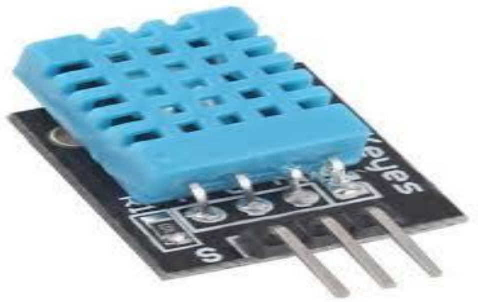

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Fig 4.3 DHT11 Sensor

➢ **Features of DHT11 Sensor**

- Temperature measurement: -20°C to 50°C (-4°F to 122°F)
- Humidity measurement: 20% to 90% RH
- Accuracy: ±1°C (±1.8°F) for temperature, ±5% RH for humidity
- Output: Digital signal via a single wire interface
- Power supply: 3.3V to 5V
- Low power consumption: 1.5mA (max)

4.4 16x2 LCD Display:

The 16x2 LCD (Liquid Crystal Display) is a widely used, low-cost display device that provides a simple and effective way to display text and numeric data. With its compact size and high visibility, the 16x2 LCD is an ideal choice for various applications, such as industrial control panels, medical devices, and electronic gadgets. The display consists of two lines, each capable of displaying 16 characters, making it suitable for displaying short messages, status updates, and numeric values. The 16x2 LCD typically uses an HD44780 controller and communicates with microcontrollers via a serial interface, making it easy to integrate into various projects.

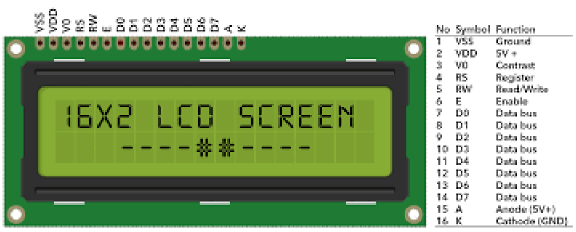


Fig 4.4 LCD Display

➢ **Features of LCD Display**

- Display Type: Alphanumeric character display
- Character Format: 5x8 dots matrix format
- Display Size: 16 characters x 2 lines
- Display Color: Blue or Green
- Backlight: LED backlight
- Voltage Supply: 5V DC
- Operating Temperature: -20°C to +70°C
- Interface: 4-bit or 8-bit mode
- Dimension: 84.0 x 44.0 x 13.0 mm

4.5 Resistors:

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. High-power resistors that can dissipate many watts of electrical power as heat may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

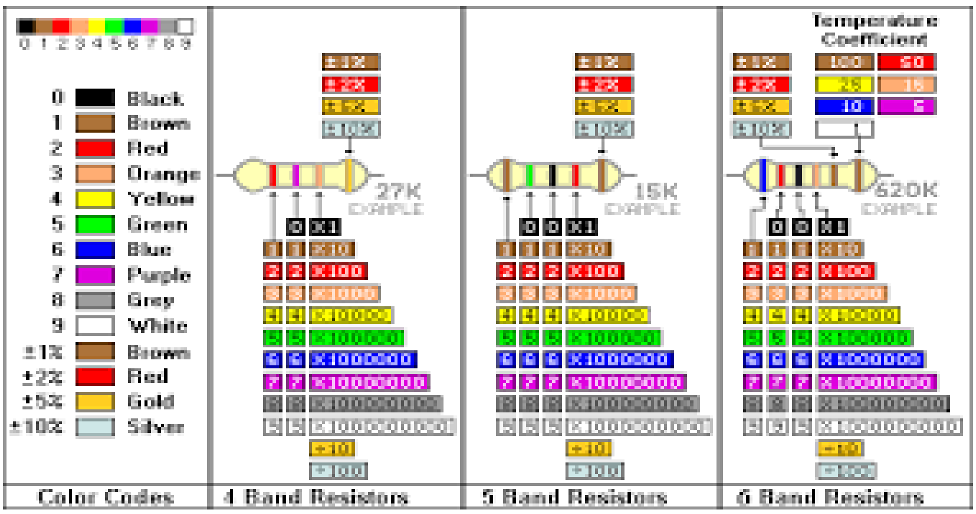


Fig 4.5 Resistor Color Code Bands & Other Component Identification

4.6 Jumper Wires:

Jumper wires are used to inter connect components perfectly. The resistance offered by these wires is up to 3 megaohms. There are three types:

- Female-Female (Fig 3.4)
- Male-Male (Fig 3.5)
- Male-Female (Fig 3.6)

Fig 4.6 Female-Female Connector

Fig 4.7Male-Male Connector

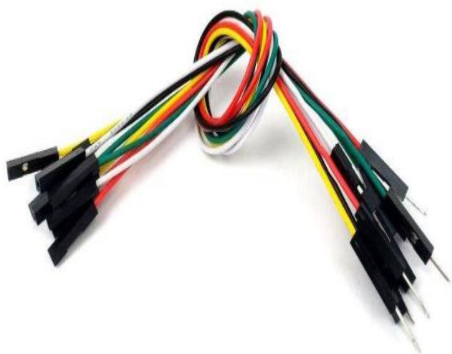


Fig 4.8 Male-Female Connector

4.7 Light Emitting Diodes (LEDs):

Light Emitting Diode or simply LED is one of the most commonly used sources of light now-a-days. Unlike (almost) legacy filament bulbs, LEDs (and fluorescent bulbs) need a special circuit to make them work. They are simply called as LED Drivers. The reason for such wide range of implementation of LEDs is its advantages over traditional incandescent bulbs and the recent compact fluorescent lamps (CFL). Few advantages of LEDs over incandescent and CFL light sources are mentioned below:

- Low Power Consumption
- Small Size
- Fast Switching
- Physically Robust
- Long Lasting

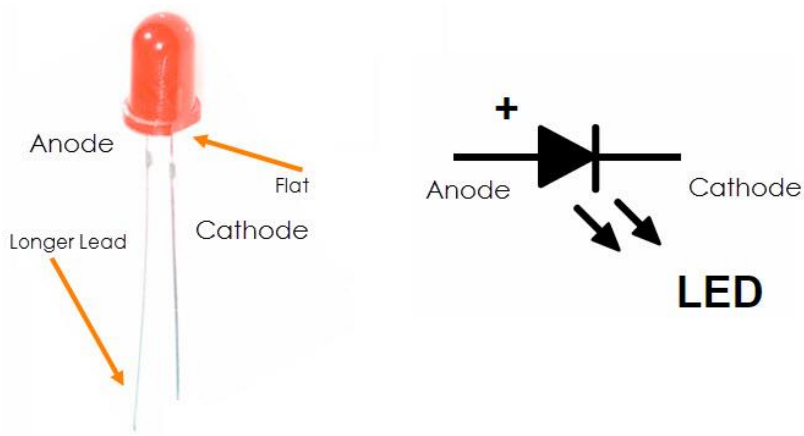


Fig 4.9 LED

In an LED, the positive terminal is called as Anode and the negative terminal is called as Cathode. For the LED to work properly, the Anode of the LED should be at a higher potential than the Cathode as the current in LED flows from Anode to Cathode.

Table 4.2 Color LED details

COLOR	WAVELENGTH (NM)	TYPICAL EFFICACY (LM/W)	TYPICAL EFFICACY (W/W)
Red	620 – 645	72	0.39
Green	520 – 550	93	0.15
Blue	460 – 490	37	0.35
Cyan	490 – 520	75	0.26
Red - Orange	610 – 620	98	0.29

4.8 Buzzer:

A buzzer is an electronic component that produces sound when an electrical signal is applied, often used for alarms, alerts, or notifications in various devices.

- **Types of Buzzers:**
- **Electromechanical Buzzers:** These buzzers use a coil of wire and a diaphragm to produce sound, similar to a doorbell.
- **Piezoelectric Buzzers:** These buzzers use a piezoelectric element (a material that generates electricity when deformed) to vibrate and produce sound.
- **Magnetic Buzzers:** These buzzers use a coil of wire and a vibrating disk to create sound.

Fig 4.10 Buzzer

4.9 Gas sensor MQ4:

The MQ4 gas sensor is a highly sensitive and reliable sensor designed to detect methane and natural gas concentrations in the air. With its fast response time and stable performance, the MQ4 sensor is an ideal component for various applications, including gas leakage detection systems, industrial safety equipment, and environmental monitoring devices. This sensor works on the principle of a chemical reaction between the target gas and the sensor's material, which triggers a change in electrical resistance. By measuring this resistance change, the MQ4 sensor can provide accurate and reliable readings of gas concentrations in the air.

- **specifications:**

1. **Sensor Details:**

- Detection Gas: Natural gas/Methane (CH_4)
- Detection Concentration: 200-10000ppm

- Sensitivity: Good for combustible gas in a wide range, high sensitivity to CH_4 and natural gas

2. **Electrical Specifications:**

- Operating Voltage: 5V ± 0.1V
- Power Consumption: Less than 750mW
- Digital Output: TTL compatible (0.1V and 5V)
- Analog Output: 0.1-0.3V (relative to pollution), maximum concentration voltage around 4V

3. **Physical and Environmental Specifications:**

- Operating Temperature: -10°C to 50°C (14°F to 122°F)
- Relative Humidity: Less than 95% RH
- Load Resistance: 20KΩ
- Sensing Resistance**:** 10KΩ-60KΩ (1000ppm CH_4)

4. **Applications:**

- Gas leakage detection equipment for homes and industries.
- Industrial combustible gas detectors.
- Portable gas detectors.
- Gas leak alarms.

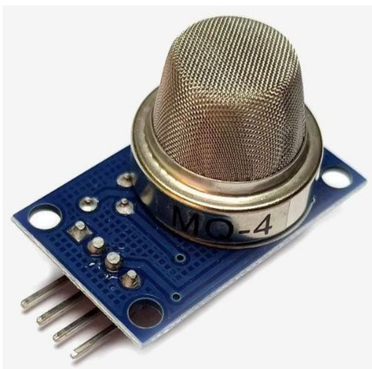


Fig 4.11 Gas Sensor MQ4

4.10 Arduino IDE:

Before we start controlling the world around us, we need to set up the software to program our board.The Arduino Software (IDE) allows us to write programs and upload them to our board.

In the Arduino Software page we will find two options:

If we have a reliable Internet connection, we should use the online IDE (Arduino Web Editor). It will allow us to save our sketches in the cloud, having them available from any device and backed up. We will always have the most up-to-date version of the IDE without the need to install updates or community generated libraries.

If we would rather work offline, we should use the latest version of the desktop IDE.

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. This software can be used with any Arduino board.

- **Arduino IDE Versions:**
  - Arduino IDE 1.8.19
  - Previous Release 1.8.18
  - Arduino 1.0.x
  - Arduino 1.5.x beta
  - Arduino 1.9.x beta

4.11 Thingspeak:

ThingSpeak is an open-source Internet of Things (IoT) platform that enables users to collect, store, and analyze data from sensors and devices in real-time. Developed by MathWorks, ThingSpeak provides a cloud-based infrastructure for IoT applications, allowing users to create customized dashboards, visualize data, and develop interactive applications. With its ease of use, scalability, and flexibility, ThingSpeak has become a popular choice among makers, hobbyists, and professionals for IoT projects, including environmental monitoring, home automation, and industrial control systems. By leveraging ThingSpeak's APIs and integration with various hardware platforms, users can build innovative IoT solutions that transform data into actionable insights.

\

Fig 4.12 Data to Thingspeak IoT Platform

CHAPTER – 5

METHODOLOGY

The project employs an integrated approach combining sensors, microcontrollers, and IoT technologies for food spoilage detection.

The methodology is divided into four steps:

5.1 Step 1: Component Integration

- **Hardware Components**

1. Sensors:
    - DHT11 measures temperature and humidity.
    - Gas sensor (e.g.,MQ4) detects spoilage gases such as ammonia or methane.
2. Microcontroller: NodeMCU ESP8266 processes sensor data and handles IoT connectivity.
3. Display: LCD for local monitoring of environmental conditions.

- **Software Components**

1. Programming Language: Arduino IDE or suitable programming language for NodeMCU.
2. IoT Platform: ThingSpeak for data storage and analysis.

5.2 Step 2: Data Collection and Processing

1. Data Collection: Sensors collect data periodically (e.g., every 5 minutes).
2. Data Evaluation: NodeMCU evaluates conditions against preset thresholds for safe storage.
3. Data Processing: NodeMCU processes data and prepares it for transmission to the IoT platform.

5.3 Step 3: IoT Integration

1. Data Transmission: NodeMCU transmits sensor data to the IoT platform via Wi-Fi.
2. Notification System: Notifications (alerts/warnings) are triggered when sensor readings indicate potential spoilage.
3. Cloud Storage: Data is stored in the cloud for further analysis and monitoring.

5.4 Step 4: Real-Time Monitoring and Alerts

1. Local Monitoring: LCD displays current temperature, humidity, and gas levels.
2. Remote Monitoring: Users can monitor conditions remotely via a web or mobile app.
3. Alerts and Notifications: Users receive notifications via email.

5.5 System Design Considerations

1. Power Supply: Ensure a stable power supply for the NodeMCU and sensors.
2. Sensor Calibration: Calibrate sensors for accurate readings.
3. Threshold Setting: Set appropriate thresholds for safe storage conditions.
4. Security: Implement security measures to prevent unauthorized access to the system.

5.6 Implementation Plan

1. Hardware Setup: Set up NodeMCU, sensors, and LCD.
2. Software Development: Develop code for data collection, processing, and transmission.
3. Testing and Validation: Test the system for accuracy and reliability.
4. Deployment: Deploy the system in a real-world setting.

CHAPTER – 6

IMPLEMENTATION

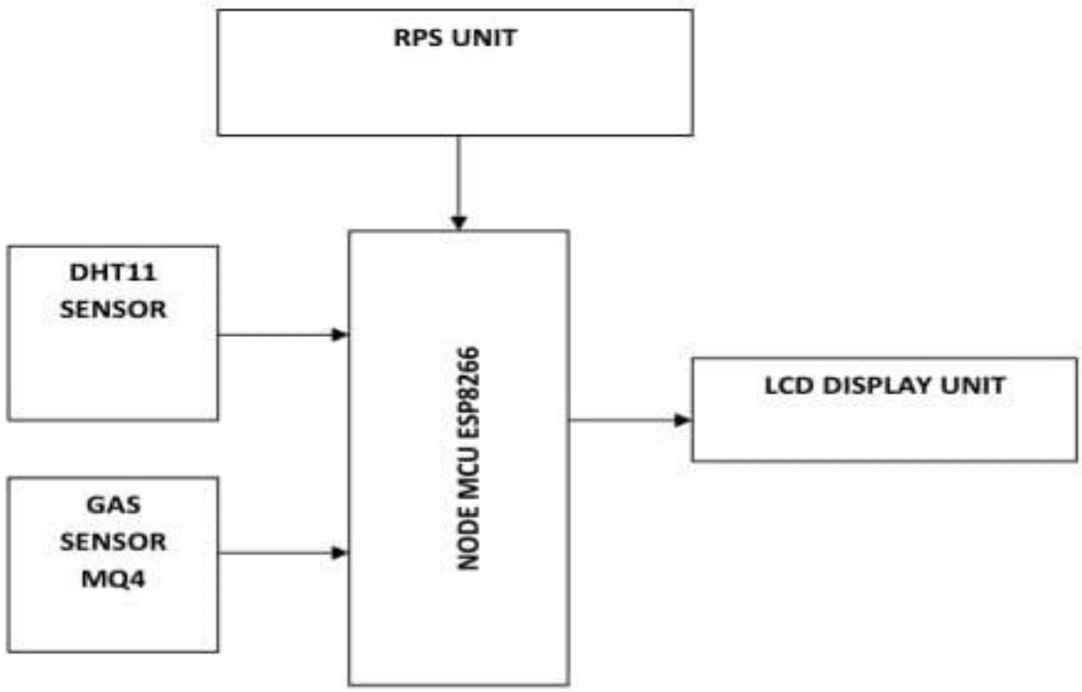


Fig 6.1 Block Diagram

6.1 Gas sensor MQ4:

MQ4 methane gas sensor is a MOS (metal oxide semiconductor) type sensor, used to detect the methane gas concentration within the air at either home or industries & generates output like analog voltage by reading it. Here, the range of concentration for sensing ranges from 300 pm – 10,000 ppm which is appropriate for the detection of a leak.

The MQ4 methane gas sensor is extremely used for detecting gas leakage at home or in industries like Methane (CH_4) & CNG Gas. This gas sensor is highly responsive in very little time, so based on the sensitivity requirements; it can be adjusted through a potentiometer. This is an analog output sensor, used like a CNG (compressed natural gas) sensor within the series of MQ sensors.

So this sensor is suitable for detecting the concentration of natural gas like methane within the air. For this sensor, if the gas concentration increases the output voltage will be increased. This sensor works with 5V DC and draws 750 mW around.

Applications:

- This sensor is used in gas leakage detecting devices for homes, industries, offices, etc.
- These sensors detect the methane & natural gases.
- Used in portable gas detectors.
- Industrial Combustible gas detector.
- Gas leak alarm.

6.2 Wiring a MQ4 Gas Sensor to NodeMCU-ESP8266:

Now that we have a complete understanding of how the MQ4 Gas Sensor works we can start connecting it to our NodeMCU! Connecting the MQ4 Gas Sensor to NodeMCU-ESP8266.Also connecting other components like DHT11 Sensor, 16x2 LCD Display.

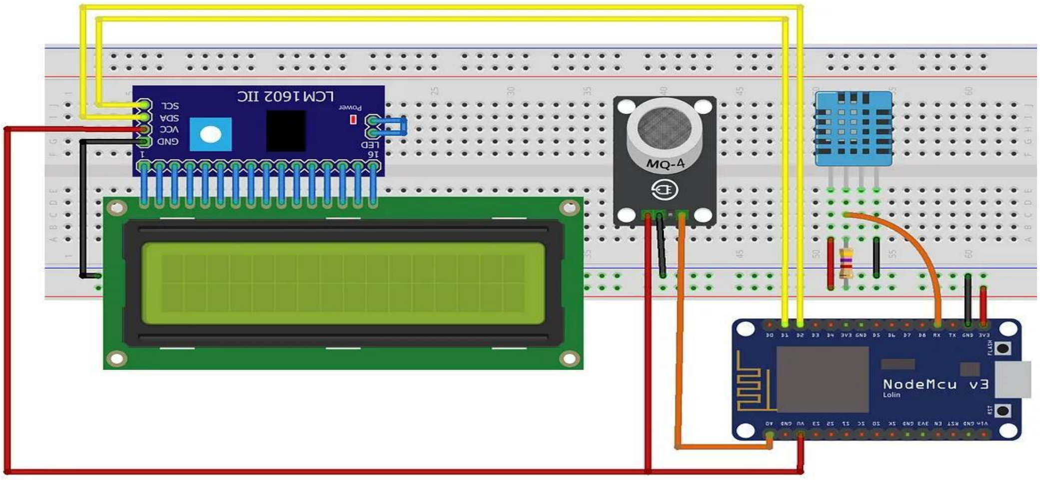


Fig 6.2 Connecting a MQ4 Gas Sensor to NodeMCU-ESP8266

Start by Connect the VCC (3V) pin to the 3.3V pin on the NodeMCU and the GND pin to the ground pin. Now connect the SCL pin of LCD to D1 and SDA pin of LCD to D2 on NodeMCU respectively. D6 pin to Buzzer, D0 pin to LED and D4 pin to DHT11 Sensor on respectively. When you are done you should have something that looks similar to the illustration shown in Fig 5.2.

Table 6.1 Pin Wiring

NodeMCU-ESP8266	Other Components
D1 (GPIO 5)	SCL OF LCD
D2 (GPIO 4)	SDA OF LCD
+5 VOLT	VCC OF LCD
GROUND	VDD OF GND
D6 (GPIO 12)	BUZZER
D0 (GPIO 16)	LED
D4 (GPIO 2)	DHT11 SENSOR

6.3 Code Explanation:

This code appears to be a setup for an IoT project using an ESP8266 board, DHT11 temperature and humidity sensor, MQ4 gas sensor, and ThingSpeak cloud platform.

#include <DHT.h> //Includes the DHT library for the DHT11 temperature and humidity sensor.

#include <ESP8266WiFi.h> //Includes the ESP8266 WiFi library for connecting to WiFi networks.

#include <Wire.h> //Includes the Wire library for I2C communication.

#include <LiquidCrystal_I2C.h> //Includes the LiquidCrystal_I2C library for the LCD display.

#include <ThingSpeak.h> //Includes the ThingSpeak library for sending data to the ThingSpeak cloud platform.

#define statements: Define pin connections and constants for the DHT11 sensor, gas sensor, LED, and buzzer.

#define DHTPIN D5

```
#define DHTTYPE DHT11
#define GAS_SENSOR_PIN A0
#define LED_PIN D0
#define BUZZER_PIN D6
DHT dht(DHTPIN, DHTTYPE);
LiquidCrystal_I2C lcd(0x27, 16, 2); // Adjust the address if necessar
void setup() {
Serial.begin(115200);
dht.begin();
lcd.init();
lcd.clear();
lcd.backlight();
lcd.setCursor(0, 0);
lcd.print("PROJECT SUBMITED");
lcd.setCursor(0, 1);
lcd.print("      BY      ");
delay(3000);
```

CHAPTER – 7

RESULTS & DISCUSSIONS

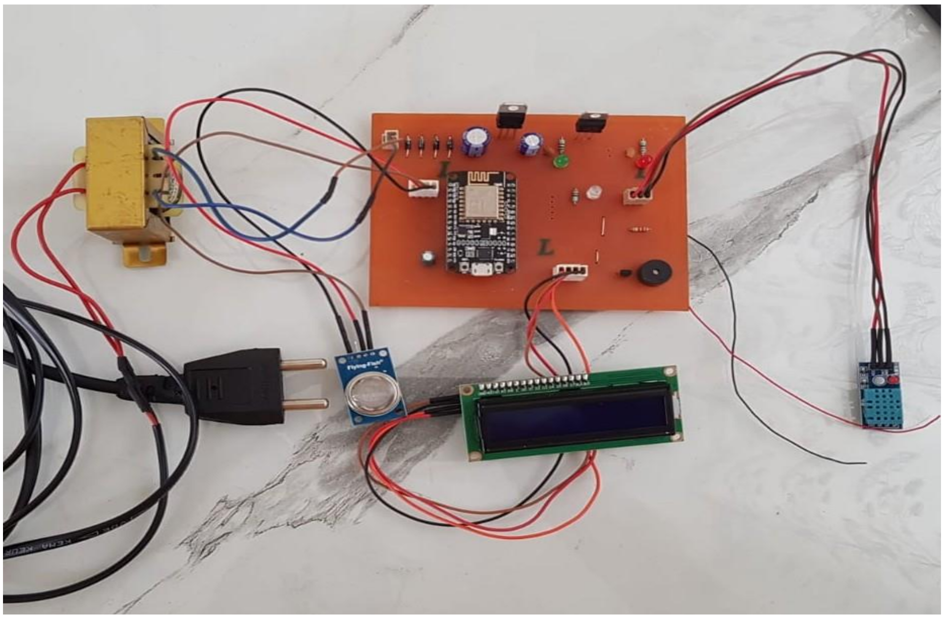


Fig 7.1 Making of project on the board

Fig 7.1 is explaining the on board connections made to perform

1) Collect all components
2) Connect NodeMCU-ESP8266 board to PC
3) Write program in Arduino IDE development platform
4) Upload the program on to microcontroller at NodeMCU kit
5) Do connect Gas sensor and LED as per circuit designed
6) Observe results for test, record, rebuild and etc procedures to achieve accurate results

7.2 Temperature, Humidity, Gas level Testing

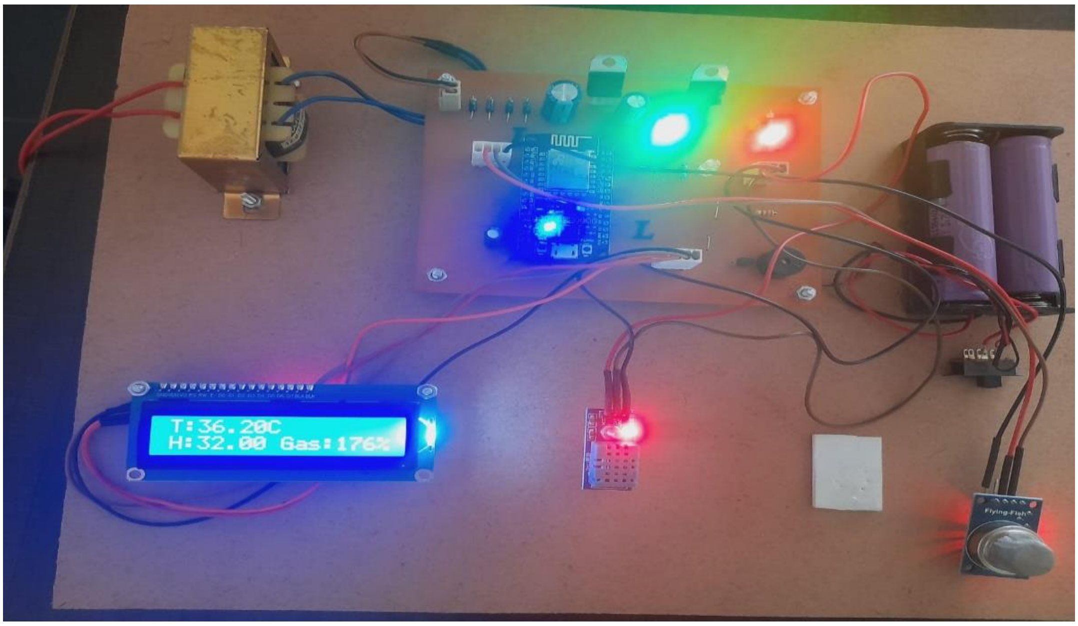
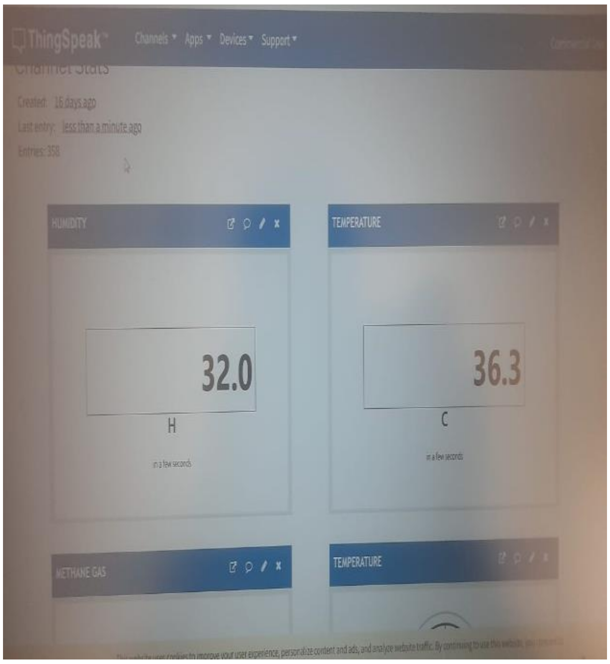


Fig 7.2 Reading displayed on LCD display

The image depicts a project on food spoiling detection using IoT, with the reading displayed on an LCD screen. It likely uses sensors to monitor food conditions and transmits data via IoT for analysis. The readings on LCD display is displaying temperature , humidity, gas.



Here the results obtained by testing spoiled food. The readings for temperature, humidity and gas , transmitted via IoT for analysis, are displayed on Thingspeak, an IoT analytics platform.

Fig 7.3 Result on Thingspeak

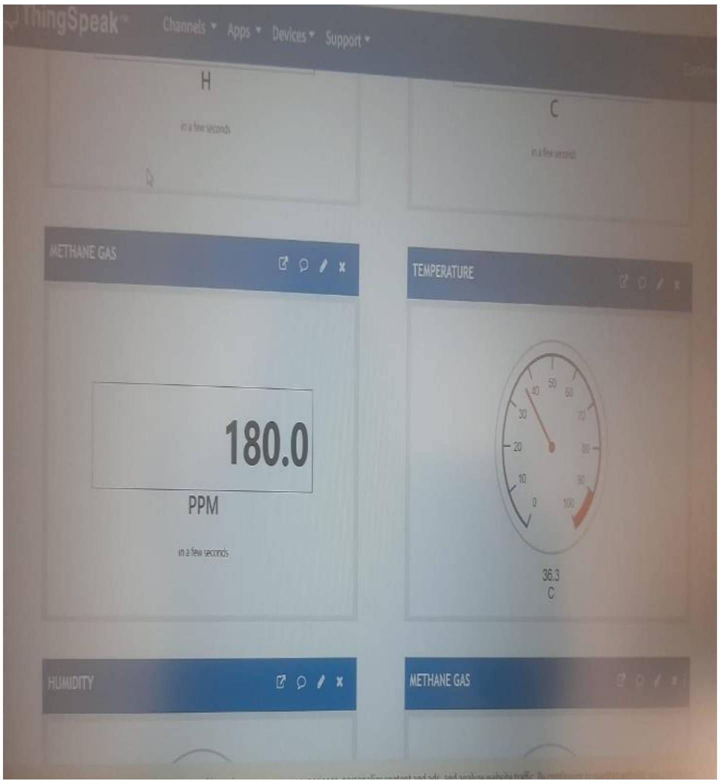


Fig 7.4 Methane gas level on Thingspeak

The image shows a dashboard from Thingspeak monitoring methane gas. The methane gas level is at 180.0 PPM.

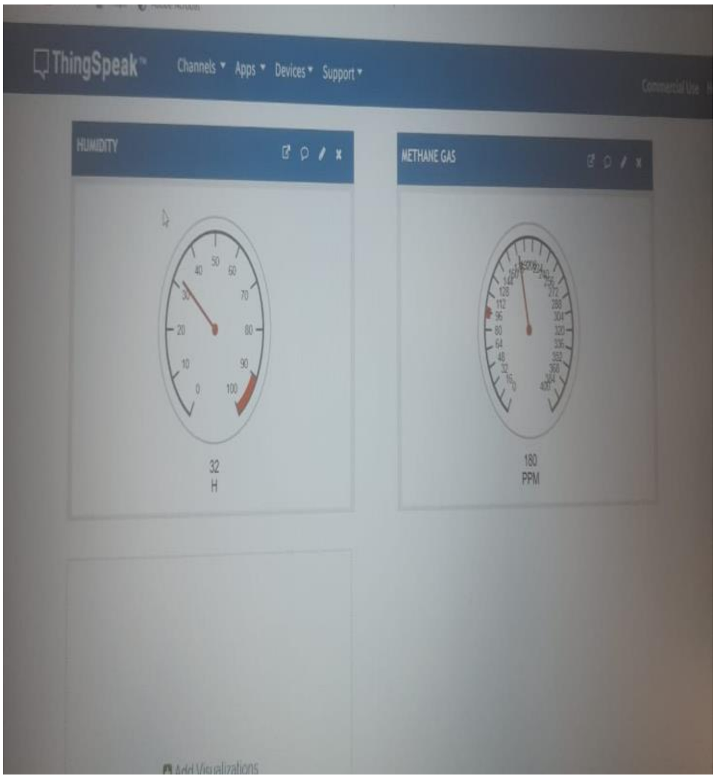


Fig 7.5 Readings Shows in analog dial scale

The image shows a screenshot of the ThingSpeak platform, displaying real-time data from analog dial scales for humidity and methane gas levels.

CHAPTER – 8

APPLICATIONS & ADVANTAGES

MQ4 Gas Sensor applications and use cases:

The MQ4 gas sensor has a wide range of applications and use cases due to its high sensitivity to methane and natural gas. Here are some examples:

8.1 Applications:

- Gas Leakage Detection: MQ4 sensors can be used to detect gas leaks in homes, industries, and commercial buildings, providing an early warning system to prevent accidents.
- Industrial Safety: The sensor can be used in industrial settings to monitor gas levels and prevent explosions or fires.
- Environmental Monitoring: MQ4 sensors can be used to monitor methane levels in the environment, helping to identify potential sources of pollution.
- Smart Home Systems: The sensor can be integrated into smart home systems to provide real-time gas monitoring and alerts.

8.2 Use Cases:

- Gas Leak Alarms: MQ4 sensors can be used in gas leak alarms to detect methane and natural gas leaks in homes and industries.
- Industrial Process Control: The sensor can be used to monitor gas levels in industrial processes, such as in chemical plants or oil refineries.
- Methane Detection in Mines: MQ4 sensors can be used to detect methane levels in mines, helping to prevent explosions and ensure miner safety.
- Gas Detection in Confined Spaces: The sensor can be used to detect gas levels in confined spaces, such as tanks or pipes, to ensure safe working conditions.

8.3 Benefits:

- Early Warning System: MQ4 sensors provide an early warning system for gas leaks, helping to prevent accidents and ensure safety.

- High Sensitivity: The sensor's high sensitivity allows it to detect even small concentrations of methane and natural gas.
- Reliable Performance: MQ4 sensors are known for their reliable performance and stability, making them suitable for critical applications.
- Low Maintenance: The sensor requires low maintenance and can be easily integrated into various systems.

Application of this project:

Households: Preventing spoilage of perishable items like fruits, vegetables, and dairy.

Food Storage: Monitoring conditions in warehouses, cold storage units, and grocery stores.

Healthcare: Ensuring safe storage of food in hospitals and care facilities.

8.4 Advantages of this project:

- Real-time monitoring ensures timely detection and response.
- Cost-effective solution using readily available components.
- Scalable system that can be adapted for various storage setups.

8.5 Disadvantage of this project:

- Wi-Fi connectivity problems can disrupt data transmission. Notifications may not be sent.
- Regular maintenance is necessary. Sensors may need calibration.
- Users may need training to use the system. Adoption rates may be low.
- System may be vulnerable to cyber attacks. Data breaches can occur.
- System relies on preset thresholds. Thresholds may not account for all scenarios.

CONCLUSION & FUTURE SCOPE

IoT-based food spoilage detection system successfully developed and demonstrated in this project offers a promising solution to improve food safety and quality. By leveraging sensors and IoT technology, the system provides real-time monitoring and alerts, enabling consumers to take prompt action to prevent foodborne illnesses and reduce food waste. The project's findings highlight the potential for widespread adoption in various industries, including food production, storage, and transportation.

Future Scope:

- ✓ Integration with AI/ML for predictive analysis of food spoilage.
- ✓ Expansion to include more sensors for detecting specific food spoilage markers.
- ✓ Improved connectivity and cloud integration for enhanced data analytics.
- ✓ Integrating the system with smart refrigerators to automatically track and monitor food freshness.
- ✓ Expanding the system to detect spoilage in other types of food, such as meat, dairy, and baked goods.

This project combines IoT, sensor technology, and real-time monitoring to create a reliable food spoilage detection system, promoting safety and reducing waste.

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APPENDIX

ESP8266 Microcontroller

Features

- Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106
- Operating Voltage: 3.3V
- Input Voltage: 7-12V
- Digital I/O Pins (DIO): 16
- Analog Input Pins (ADC): 1
- UARTs: 1
- SPIs: 1
- I2Cs: 1
- Flash Memory: 4 MB
- SRAM: 64 KB
- Clock Speed: 80 MHz
- USB-TTL based on CP2102 is included onboard, Enabling Plug n Play PCB Antenna
- Small Sized module to fit smartly inside your IoT projects

1. Pin Configurations

Table 1-1. Specifications

Categories	Items	Parameters
Wi-Fi	Certification	Wi-Fi Alliance
	Protocols	802.11 b/g/n (HT20)
	Frequency Range	2.4G ~ 2.5G (2400M ~ 2483.5M)
	TX Power	802.11 b: +20 dBm
		802.11 g: +17 dBm
		802.11 n: +14 dBm
	Rx Sensitivity	802.11 b: –91 dbm (11 Mbps)
		802.11 g: –75 dbm (54 Mbps)
		802.11 n: –72 dbm (MCS7)
	Antenna	PCB Trace, External, IPEX Connector, Ceramic Chip
Hardware	CPU	Tensilica L106 32-bit processor
	Peripheral Interface	UART/SDIO/SPI/I2C/I2S/IR Remote Control
		GPIO/ADC/PWM/LED Light & Button
	Operating Voltage	2.5V ~ 3.6V
	Operating Current	Average value: 80 mA
	Operating Temperature Range	–40°C ~ 125°C
	Package Size	QFN32-pin (5 mm x 5 mm)
	External Interface	-
Software	Wi-Fi Mode	Station/SoftAP/SoftAP+Station
	Security	WPA/WPA2
	Encryption	WEP/TKIP/AES
	Firmware Upgrade	UART Download / OTA (via network)
	Software Development	Supports Cloud Server Development / Firmware and SDK for fast on-chip programming
	Network Protocols	IPv4, TCP/UDP/HTTP
	User Configuration	AT Instruction Set, Cloud Server, Android/iOS App

Note:
The TX power can be configured based on the actual user scenarios.

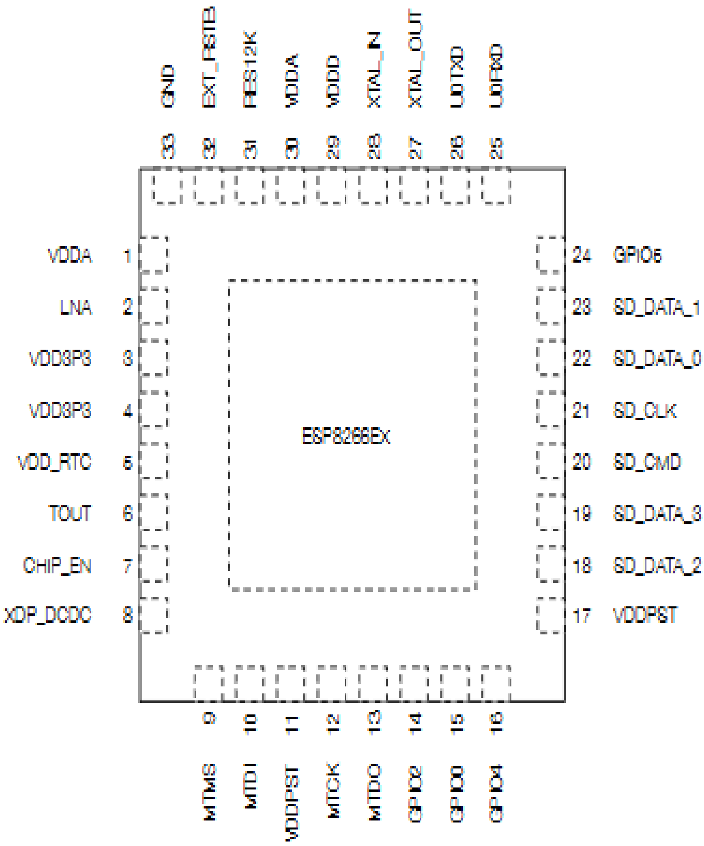


Figure 2-1. Pin Layout (Top View)

Table 2-1 lists the definitions and functions of each pin.

Table 2-1. ESP8266EX Pin Definitions

Pin	Name	Type	Function
1	VDDA	P	Analog Power 2.5V ~ 3.6V
2	LNA	I/O	RF antenna interface Chip output impedance=39+j6 Ω. It is suggested to retain the π-type matching network to match the antenna.
3	VDD3P3	P	Amplifier Power 2.5V ~ 3.6V
4	VDD3P3	P	Amplifier Power 2.5V ~ 3.6V
5	VDD_RTC	P	NC (1.1V)
6	TOUT	I	ADC pin. It can be used to test the power-supply voltage of VDD3P3 (Pin3 and Pin4) and the input power voltage of TOUT (Pin 6). However, these two functions cannot be used simultaneously.

Pin	Name	Type	Function
7	CHIP_EN	I	Chip Enable High: On, chip works properly Low: Off, small current consumed
8	XPD_DCDC	I/O	Deep-sleep wakeup (need to be connected to EXT_RSTB); GPIO16
9	MTMS	I/O	GPIO 14; HSPI_CLK
10	MTDI	I/O	GPIO 12; HSPI_MISO
11	VDDPST	P	Digital/IO Power Supply (1.8V ~ 3.6V)
12	MTCK	I/O	GPIO 13; HSPI_MOSI; UART0_CTS
13	MTDO	I/O	GPIO 15; HSPI_CS; UART0_RTS
14	GPIO2	I/O	UART TX during flash programming; GPIO2
15	GPIO0	I/O	GPIO0; SPI_CS2
16	GPIO4	I/O	GPIO4
17	VDDPST	P	Digital/IO Power Supply (1.8V ~ 3.6V)
18	SDIO_DATA_2	I/O	Connect to SD_D2 (Series R: 200Ω); SPIHD; HSPIHD; GPIO9
19	SDIO_DATA_3	I/O	Connect to SD_D3 (Series R: 200Ω); SPIWP; HSPIWP; GPIO10
20	SDIO_CMD	I/O	Connect to SD_CMD (Series R: 200Ω); SPI_CS0; GPIO11
21	SDIO_CLK	I/O	Connect to SD_CLK (Series R: 200Ω); SPI_CLK; GPIO6
22	SDIO_DATA_0	I/O	Connect to SD_D0 (Series R: 200Ω); SPI_MISO; GPIO7
23	SDIO_DATA_1	I/O	Connect to SD_D1 (Series R: 200Ω); SPI_MOSI; GPIO8
24	GPIO5	I/O	GPIO5
25	U0RXD	I/O	UART Rx during flash programming; GPIO3
26	U0TXD	I/O	UART TX during flash programming; GPIO1; SPI_CS1
27	XTAL_OUT	I/O	Connect to crystal oscillator output, can be used to provide BT clock input
28	XTAL_IN	I/O	Connect to crystal oscillator input
29	VDDD	P	Analog Power 2.5V ~ 3.6V
30	VDDA	P	Analog Power 2.5V ~ 3.6V
31	RES12K	I	Serial connection with a 12 kΩ resistor and connect to the ground
32	EXT_RSTB	I	External reset signal (Low voltage level: active)

Note:

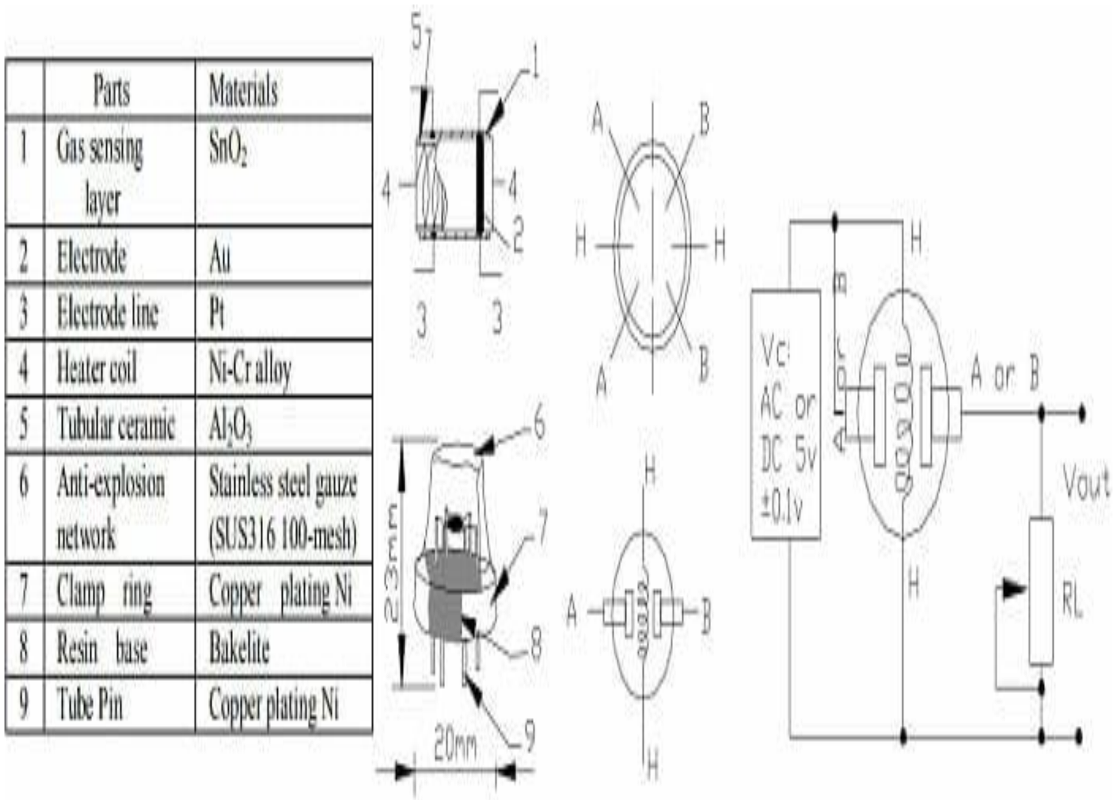
1. *GPIO2, GPIO0, and MTDO are used to select booting mode and the SDIO mode;*
2. *U0TXD should not be pulled externally to a low logic level during the powering-up.*

Gas Sensor MQ4

Features

- Detection Gas: Natural gas/Methane (CH4)
- Detection Concentration: 200-10000ppm
- Sensitivity: Good for combustible gas in a wide range, high sensitivity to CH4 and natural gas
- Operating Voltage: 5V ± 0.1V
- Power Consumption: Less than 750mW
- Digital Output: TTL compatible (0.1V and 5V)
- Analog Output: 0.1-0.3V (relative to pollution), maximum concentration voltage around 4V
- Operating Temperature: -10°C to 50°C (14°F to 122°F)
- Relative Humidity: Less than 95% RH
- Load Resistance: 20KΩ
- Sensing Resistance**:** 10KΩ-60KΩ (1000ppm CH4)

1. Pin Configurations



	Parts	Materials
1	Gas sensing layer	SnO_2
2	Electrode	Au
3	Electrode line	Pt
4	Heater coil	Ni-Cr alloy
5	Tubular ceramic	Al_2O_3
6	Anti-explosion network	Stainless steel gauze (SUS316 100-mesh)
7	Clamp ring	Copper plating Ni
8	Resin base	Bakelite
9	Tube Pin	Copper plating Ni

2. Datasheet of Gas sensor

SPECIFICATIONS

A. Standard work condition

Symbol	Parameter name	Technical condition	Remarks
Vc	Circuit voltage	5V±0.1	AC OR DC
V_H	Heating voltage	5V±0.1	ACOR DC
P_L	Load resistance	20KΩ	
R_H	Heater resistance	33Ω±5%	Room Tem
P_H	Heating consumption	less than 750mw	

B. Environment condition

Symbol	Parameter name	Technical condition	Remarks
Tao	Using Tem	-10℃-50℃	
Tas	Storage Tem	-20℃-70℃	
R_H	Related humidity	less than 95%Rh	
O_2	Oxygen concentration	21%(standard condition)Oxygen concentration can affect sensitivity	minimum value is over 2%

C. Sensitivity characteristic

Symbol	Parameter name	Technical parameter	Ramark 2
Rs	Sensing Resistance	10KΩ - 60KΩ (1000ppm CH_4)	Detecting concentration scope: 200-10000ppm CH_4, natural gas
α (1000ppm/ 5000ppm CH_4)	Concentration slope rate	≤0.6	
Standard detecting condition	Temp: 20℃±2℃ Vc:5V±0.1 Humidity: 65%±5% Vh: 5V±0.1		
Preheat time	Over 24 hour		

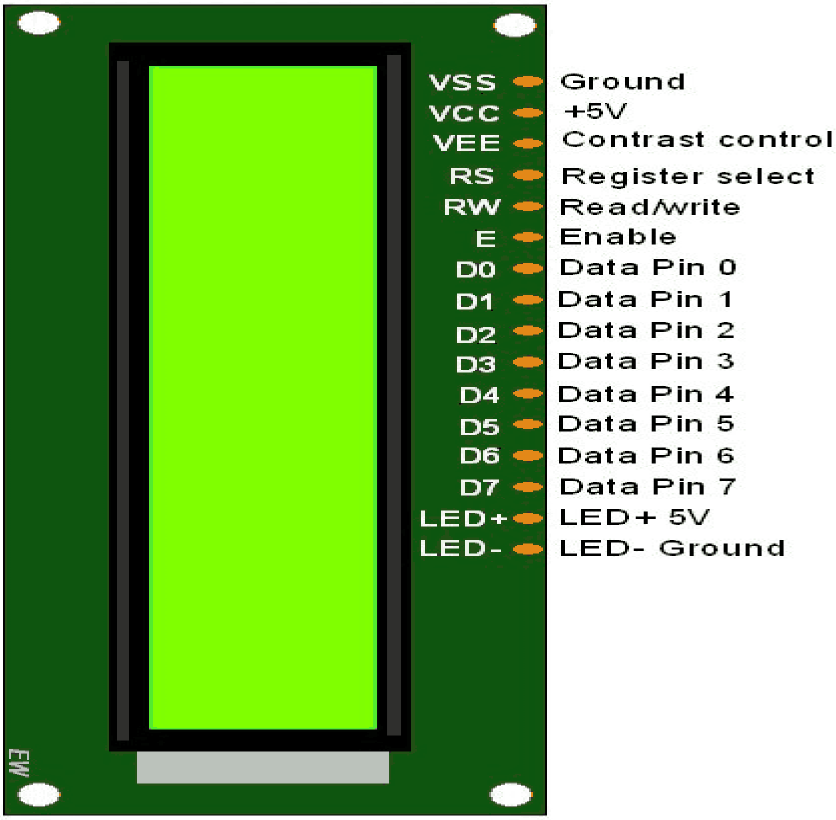
D. Strucvure and configuration. basic measuring circuit

LCD Display

Features of LCD16x2

- The operating voltage of this LCD is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight
- Every character can be built with a 5×8 pixel box
- The alphanumeric LCDs alphabets & numbers
- Is display can work on two modes like 4-bit & 8-bit
- These are obtainable in Blue & Green Backlight
- It displays a few custom generated characters

1. Pin Configurations



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