**FOOD FRESHNESS DETECTION**

**ABSTRACT**

In today’s world, food spoilage is a crucial problem as consuming spoiled food is harmful for consumers. Our project aims at detecting spoiled food using appropriate sensors and monitoring gases released by the senses this, issues an alert using internet of things, so that appropriate action can be taken. This has wide scale application in food industries where food detection is done manually. We plan on implementing machine learning to this model so we can estimate how likely food is going to get spoiled and in what duration, if brought from a particular vendor. This will increase competition among retailers to sell more healthy and fresh food and create a safe world for all consumers alike.

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**RUTHU R (1DB18TE010)**

**POORVITHA H R (1DB18TE009**)

**TABLE OF CONTENTS**

**CERTIFICATE**

**ABSTRACT**

**ACKNOWLEDGEMENT**

**LIST OF FIGURES**

**CHAPTER 1 INTRODUCTION**

1.1 LITERATURE SURVEY

1.2 PROBLEM FORMULATION

1.3 MOTIVATION

1.4 OBJECTIVE

1.5 SCOPE OF PROJECT

1.6 REPORT ORGANISATION

**CHAPTER 2 EXISTING METHODOLOGY**

**CHAPTER 3 PROPOSED METHODOLOGY**

3.1 EARLIER FOOD FRESHNESS DETECTORS

3.2 WORKING ON FOOD FRESHNESS DETECTIONs

**CHAPTER 4 RESULTS**

4.1 APPLICATION

4.2 ADVANTAGES

4.3 DISADVANTAGES

**CHAPTER 5 CONCLUSIONS AND FUTURE SCOPE**

**REFERENCES**

**APPENDIX**

1.DATA SHEET

2.CODE

**LIST OF FIGURES**

|  |  |  |
| --- | --- | --- |
| **Fig.No** | **Description** | **Page. No** |
| 1 | Plot of cloud integrated platform | 8 |
| 2 | Architecture of CCS811(TOVC SENSOR) | 16 |
| 3 | Architecture of ESP32 microcontroller | 18 |
| 4 | Pin diagram of ESP32 microcontroller | 19 |
| 5 | Circuit Diagram | 20 |

**INTRODUCTION**

We are in the 21st century and food sector is very big part of our economy. One of the biggest problems that it faces is food spoilage that is food items, more specifically meat items or fruits and vegetables going stale. The bigger problem is these spoilt items going undetected and onto the hands of the consumer. In all fruits and vegetables industries, the process of checking of quality of items is done manually, mostly by a person sitting across a conveyor belt as the items pass by. Hence, if an automated process is brought into place, it would not only increase the accuracy of spoilt food detection, but also reduce manually manpower required.

To automate this process, we plan on using a collection of smart sensors with microcontroller like the Node Mcu. On detection of a spoilt or stale food item, a sound buzzer can be range to draw attention, moreover this data will be sent to the cloud, as an application of IOT. This enables appropriate authorities to view how often they get spoilt food items and create transparency.

**Principle of Sensing**

The detection of whether or not a food item is spoilt or not is made using the following two principle

* **Oxygen Level Detection:** The underlying theory is that if food item, say fruits or meat, is inhabited by germs, the oxygen levels in the immediate surrounding is going to be lower than it normally is. The reason being that, germs inside the food item are consuming the oxygen, and this changes in the level is what we plan to detect.
* **Ammonia Gas:** Meat items like fish, are known to release ammonia gases when they go stale. A gas sensor captures the readings of the ammonia levels near the food item, and sends an alert to the microcontroller when abnormal levels are detected.

**1.1 LITERATURE SURVEY**

**Paper 1: “EFresh – A Device to Detect Food Freshness”**

**September 2018**

In this paper authors Naveed Shahzad, Usam Khalid used biosensor and electrical sensors to check out the freshness of food. A smart system that may sight the freshness of food like farm things, meat, and fruits. The identification and choice of hydrogen ion concentration device, moisture sensor, and the gas sensor is used to develop a wise food and tells whether or not eat it or bin it. An android application is developed to select the type of food to be checked.

The system ensures the quality of food, whether it is good for eating or not. It does not provide the facility to complain if the device does not provide the facility to complain if the device does not provide device.

**Paper 2: “Detection and classification of bacteria in common street foods using electronic nose and support vector machine”2017**

Authors Jessie R. Balbin, Julius T. Sese, Crissa Vin R. Babaan focused on the classification of bacteria in the street food. Street food features a major impact on the culture and however, as a result of the dearth of information on correct food preparation, the cleanliness and quality of street food are neglected. A bad microorganism exists, by using an electronic nose, and image processing.

This paper aims to design an electronic nose with gas sensors that will detect three common types of bacteria on street foods, namely Enterococcus faecalis, Escherichia coli and Staphylococcus aureus; and to classify if the said bacteria are present in the pre-cooking stage and the bacteria are still present after cooking. The electronic nose system detects the bacteria in the sample street food during the pre-cooking stage and Support Vector Machine detects the bacteria in the sample street food during the post cooking stage. This system lacks the detection of other parameters like moisture, gas level in food.

**Paper 3: “Real-Time Milk Monitoring System”2018**

Authors Prof. Kadam P. R, Miss. Shinde K. P. describes the scenario of smart city services that are provided to manage the city's assets by integrating information and communication technology (ICT) and the Internet of things (IoT). Different sensors, terminals with a variety of topologies and different application requires security for managing them. To make money day by day the quality of food decreases and it affects the health of people and this creates food safety problems. In this paper, the presented model detects the raw milk for spoilage detection. From the last decade, researches are coming upwith different efficient methods for detecting spoilage of milk. This paper states different studies that show that raw milk contains the bacteria which are harmful to human beings, so there is a need to develop one real-time system which will monitor the quality of milk distributed to the people or getting used for dairy products. The proposed system work with a set of different sensors which are connected to the Arduino board and in turn all data will get passed to the android app and according to the value, the system checks the quality of milk and user can easily identify the quality of milk, the user is getting. Along with milk, a system must check other items which will make the system more effective.

**Paper 4: “The Vegetable Freshness Monitoring System Using RFID with Oxygen and Carbon Dioxide Sensor”2012**

In this paper authors Ki Hwan Eom, Min Chul Kim proposed an oxygen and carbonic acid gas concentration observation system for freshness management, which supports radio frequency identification (RFID). Freshness may be checked by varying factors as well as wetness, temperature, oxygen, and carbonic acid gas. This paper focuses on oxygen and carbon dioxide. The concentrations of these two gases are related to freshness and affect the food. This system uses a device for observation of gases and connects the device with the associate RFID tag. The RFID system is relatively easy to manage. With this combined system, it calculated the freshness of vegetables.

**1.2 PROBLEM STATEMENT**

 Diseases arise due to contaminated fruits and vegetables may be higher in developing countries and the concern about food safety has also increased in the last couple of years. As per World Health Organization (WHO, 1999), the number of people suffering from diseases resulting from contaminated food or water are more than hundreds of million. Fruits and vegetables are perishable in nature and also the taste, texture and aroma are subject to change with the time of plucking. Freshness is one of the crucial attribute for the selection of fruits and vegetables by the customer therefore this need to be addressed through an app. Toxicological research shows that the pesticides present in fresh fruits and vegetables are generally responsible for cancer and birth defects. This shall also affect the nervous, endocrine, reproductive and immunological system. The basic aim to identify the application of any unwanted material used on fruits and vegetables like, insecticide, wax, calcium carbide, and ethylene etc. so that the consumer will be assured about the freshness and safety. An app shall be developed which would be able to detect the freshness either using the mobile scanner, bar reader or some other means. The app would also display information on whether the fruits and vegetables are safe to consume or not. Food safety assures the minimum risk associated with the fruits and vegetables during production, storage and handling of produce.

**1.3MOTIVATION**

Thirty students from Telangana Minority Residential School in Hyderabad’s Asif Nagar were admitted to Niloufer Hospital after they fell sick eating lunch served at the mess on MONDAY, JULY 08,2019. The students suffered from vomiting and severe abdominal pain. The students were within the age range of around 10 to 13. They ate the hostel food on Sunday afternoon and immediately presented with stomach pain and vomiting. They were delivered to the hospital on Monday morning and admitted. Each year, people die from the illness. Often, people consume spoiled foods because there’s no significantly visible sign of food spoilage.

**1.4 OBJECTIVE**

Our project aim at detecting spoiled food using appropriate sensor and monitoring gases released by the particular food item.A micro controller that senses this, issues an alert using internet of things, so that appropriate action can be taken.

**1.5 SCOPE OF PROJECT**

The food we consume provides nourishment and gives energy to our body which helps us to perform our day today activities. A healthy and fresh diet is the most important way to keep ourselves fit. The food items kept at room temperature undergo rapid bacterial growth and chemical changes in food. Eating unhealthy food can cause several food borne diseases which may harm our health. This IoT based system aims to detect the quality and freshness of food using biosensor and electrical sensors. A smart system can detect the freshness of household food like dairy items, fruits, and food items. The identification and selection of a hydrogen sensor, and Gas sensor to develop a sensible food freshness detector ensures the freshness of food and tells whether or not to eat it or bin it

**1.6 REPORT ORGANIZATION**

The food we consume provide nourishment and gives energy to our body, it gives us the ability to do daily activities and help improves our health in direct as well as indirect ways. A healthy and fresh diet is the most important way to keep ourselves fit. The food items kept at room temperature undergo rapid bacterial growth and chemical changes in food. Taking unhealthy food leads to bad health, and can causes different food borne diseases. The purpose to use CCS811(TOVC SENSOR) and ESP32 microcontroller is to determine the freshness of the food. A smart system which can detect the freshness of the food like dairy items, meat, fruits, vegetables and daily consuming food Here the CCS811(TOVC SENSOR) is used to detect the amount of oxygen and ammonia content in the food.

**CHAPTER 2**

**EXISTING METHODOLOGY**

* The image processing method is use of computer algorithms to perform image processing. In order to check fruit quality, omit et al. used color, shape, and texture to sort tomato fruits according to their color(redness), size, shape, circularity, maturity and defects.
* An electronic nose term used for sensing food freshness by checking fruits optical and gaseous properties. Number of different sensors have been developed for multi-sensor arrays. These types of sensors demonstrate physical and chemical compounds when they flow over or are in contact with the chemical compounds when they over or are in contact with the sensors. The biosensors, odor systems, moisture sensors and constitutes the piezoelectric crystal sensors.
* In gas sensing two types of piezoelectric sensors are used the surface acousticwave (SAW) device and quartz crystal microbalance (BAW). The devices work on change in the mass of the piezoelectric sensor coating, the gas absorption results in change in the resonant frequency on exposure to a vapor.
* A device called food sniffer is developed to check the freshness and quality of meat items like beef, chicken and fish.

**CHAPTER 3**

**PROPOSED METHODOLOGY**

* Sensor monitors the food quality. Oxygen and ammonia sensors measure the oxygen and ammonia content for particular food item.
* Machine learning model uses trained model to predict if the given food item is spoilt or not based on the oxygen and ammonia content.
* Node Mcu(microcontroller) sounds a buzzer when it encounters a spoilt food item. This data is sent to a cloud platform.
* Number of spoilt food occurrences can be deployed again to predict shelf life of given food items.

1. **Cloud Platform Integration**

Popular cloud platform like Thingspeak can used for cloud analysis of data. For applications in food industries, we can obtain insights like:

* Occurrences of spoilt food items in a day.
* Peak time duration, in which most food items are found spoilt (day, afternoon, night). How may spoilt food items are successfully separated.
* How may spoilt food items are successfully separated.
* A sample plot on Thingspeak is shown below, which shows the number of spoilt food items on different days of the month, providing easy analysis.



Fig 1: Plot of cloud integrated platform

**3.1 EARLIER FOOD FRESHNESS DETECTORS**

* **Direct Freshness Sensors**

The direct freshness sensors directly detect or sense a particular freshness marker or compounds as an indication of the food freshness level. A variety of different freshness sensors has been proposed in the literature, such as spoilage indicators, ripeness indicators, leak indicators, and even microbial indicators. Mainly the sensors incorporated a color indicator for easy detection by the naked eye, where the rate of color change in the indicator correlated well with the rate of deterioration of the food in respect to temperature variation and time during transportation, distributed transportation, distribution and storage.

* **Indirect Freshness Sensors**

Indirect sensors work based on indirect detection of a freshness marker, where these sensors are expected to mimic the change of a certain quality parameter of the food undergoing the same exposure to temperature. In order to be used as food freshness monitoring devices, the rate of change of the sensor or indicator must correlate well with the rate of deterioration of the packaged food according to the temperature variation over time during transportation distribution and storage. Generally, as in the case of direct sensors, the indirect sensors will change color when exposed to higher than recommended storage temperatures and will also change as the product reaches the end of its shelf life. Currently, the freshness sensors that can be categorized as the indirect sensor type are temperature indicators (TI), time-temperature indicates (TTIs) and RFID (radio frequency identification).

**3.2 WORKING ON FOOD FRESHNESS DETECTION**

* **Artificial Intelligence Approach:** An alternative approach is using artificial intelligence, on which some work is being done currently. The concept is basically using computer vision and analyzing the image of a food item to conclude if it is spoilt or not. However, the problem is, by capturing images we can only get hold of an idea of the exterior of the food item and not its interior.
* **MIT research:** A MIT team has done research on this field by developing a sensor that detects spoilt meat items. But since it only detects a particular gas, it can have a lot of false negatives.

**CHAPTER 4**

**RESULTS**

* If the given input is spoilt food, then the output is sound buzzer will turn on and display food is spoilt.
* If the given input is health food, then the output issound buzzer will not turn on and display food is not spoilt.

**4.1 APPLICATION**

1. **INDUSTRAIL APPLICATION:** After making an analysis of data of spoilt food items, it can successfully predict which part of the day, are most occurrences of spoilt food items occurring. It can also be analyzed which particular food items are getting spoilt more frequently. Accordingly, more people can be employed during the peak times and less during other times. This saves considerable amount of manpower.
2. **COMMERCIAL APPLICATION:** When this concept is applied to retail stores and grocery shops, we will obtain a collective data of how frequently a food item gets spoilt if brought from a particular vendor.

This pushes vendors to sell food items that have a longer shelf life, and creates consumer awareness to buy food with longer shelf life.

1. **CONSUMER APPLICATION:** When incorporated into refrigerators, this smart sensing system can send email notifications directly user to whenever spoilt food is detected. This ensures consumers, especially children don’t consume harmful and spoilt food.

**4.2 ADVANTAGES**

1. **RETAIL STORES:** Inside shelves and containers, our array of ammonia and oxygen sensors can be placed. As spoilt food item is detected, management is altered. Also, food items having a shorter shelf life can be given a higher priority to sell first, greatly assisting the inventory management.
2. **INDUSTRY:** In the food industry, large number of items are processed along a conveyor built. Our sensors will be place across the belt, and management will be able to track, what parts of the day, most occurrences of spoilt food items took place and take action accordingly.
3. **HOUSEHOLD:** Refrigerators can have the array of sensors installed inside them. As soon as a spoilt food item is detected, a buzzer is sounded and a mail is sent to the owner, instructing them to avoid the food item.

**4.3 DISADVANTAGES**

If the given food item in huge quantity and even small number of items are spoilt but the output will be whole food is spoilt. By this i.e., if 10kgs of tomato is given in that let 1kg is spoilt but the result is the whole 10kg is spoilt and we can’t separate the remaining 9kgs of tomato from the spoilt tomato.

**CHAPTER 5**

**CONCLUSIONS AND FUTURE SCOPE**

1. **CONCLUSION**

An exhaustive research has led us to conclude that the food industry can be revolutionized by a simple combination of sensors, IOT and machine learning.

After integration, this model will create a competition between food manufactures to sell more healthy food and create awareness among consumer to purchase more healthy food.

1. **FUTURE SCOPE**

An embedded system can be installed in it which can send data to a centralized server where it can send for different research purposes and user can see history of data.

For further improvement in results, add an artificial neural network in the server which can read data and send the results to the terminal devices which can use this data for devising the better results in future about the food spoilage.

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**APPENDIX**

1. **Data Sheet**

CCS811(TOVC SENSOR)

|  |  |
| --- | --- |
| **Benefits** | **Features** |
| • Manages the sensor drive modes and measurements while detecting VOCs | • Integrated MCU |
| • Provides eCO2 level or TVOC indication with no host intervention | • On-board processing |
| • Simplifies the hardware and software integration | • Standard I²C digital interface |
| • Extend battery life in portable applications | • Optimised low-power modes |
| • Suitable for small form-factor designs | • 2.7mm x 4.0mm x 1.1mm LGA package |
| • Saves up to 60% in PCB footprint | • Low component count |
| • Designed for high volume and reliability (>5years lifetime) | • Proven technology platform |

**Applications**

This device can be mainly used for indoor air quality monitoring in:

• Smart phones

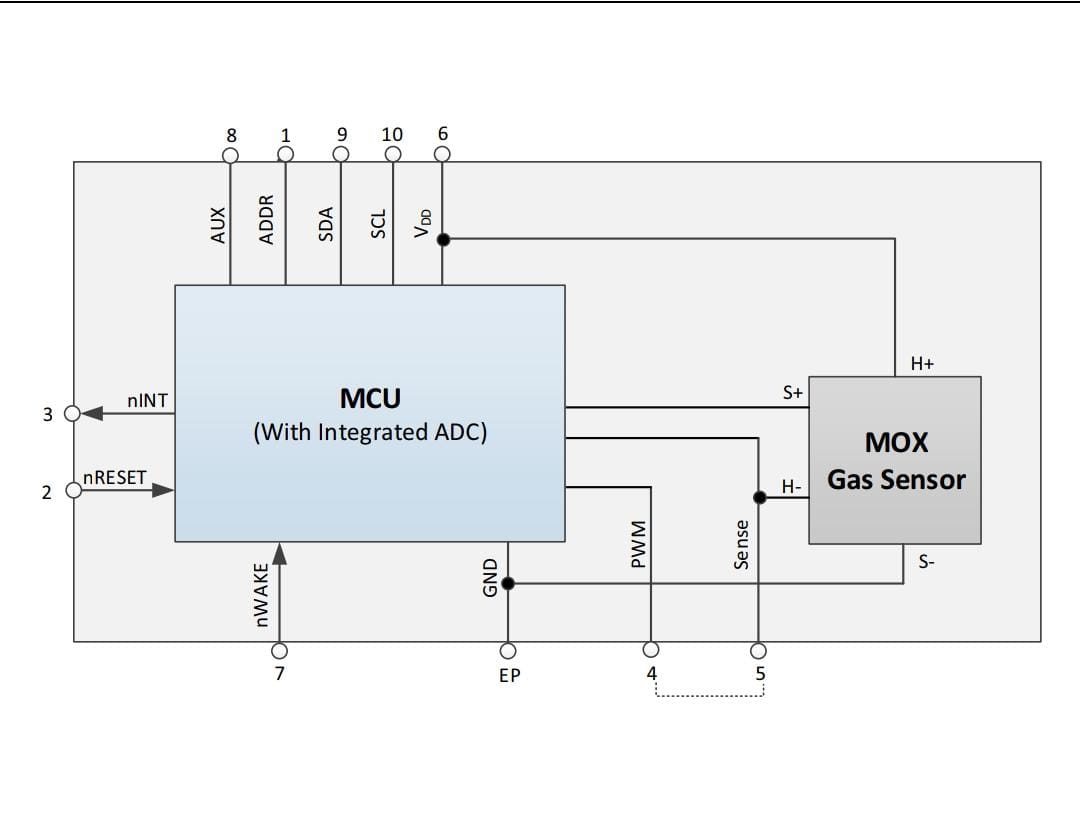
• Wearables

• Home and Building automation

• Accessories

**Block Diagram**

The functional blocks of this device are shown below:

Fig 2: Architecture CCS811(TOVC Sensor)

**CCS811 LGA Pin Assignment**

|  |  |  |
| --- | --- | --- |
| **Pin No.** | **Pin Name** | **Description** |
| 1 | ADDR | Single address select bit to allow alternate address to be selected  • When ADDR is low the 7 bit I²C address is decimal 90 / hex 0x5A  • When ADDR is high the 7 bit I²C address is decimal 91 / hex 0x5B. |
| 2 | nRESET | nRESET is an active low input and is pulled up to VDD by default. nRESET is optional but external 4.7KΩ pull-up anREnd/or decoupling of the nRESET pin may be necessary to avoid erroneous noise-induced resets. |
| 3 | nINT | nINT is an active low optional output. It is pulled low by the CCS811 to indicate end of measurement or a set threshold value has been triggered. |
| 4 | PWM | Heater driver PWM output. Pins 4 and 5 must be connected together. |
| 5 | Sense | Heater current sense. Pins 4 and 5 must be connected together |
| 6 | VDD | Supply voltage |
| 7 | nWAKE | nWAKE is an active low input and should be asserted by the host prior to an I²C transaction and held low throughout. |
| 8 | AUX | Optional AUX pin which can be used for ambient temperature sensing with an external NTC resistor. If not used leave unconnected. |
| 9 | SDA | SDA pin is used for I²C data. Should be pulled up to VDD with a resistor |
| 10 | SCL | SCL pin is used for I²C clock. Should be pulled up to VDD with a resistor |
| 11 | Exposed Pad | Connect to ground |

**ESP32 MICROCONTROLLER**

**Features**

* ESP32 also includes state-of-the-art features, such as fine-grained clock gating, various power modes and dynamic power scaling.
* ESP32 is highly integrated with in-built antenna switches, RF balun, power amplifier, low noise receiver amplifier, filters, and power management.

**Application**

* ESP32 can perform as a complete standalone system or as a slave device to a host MCU, reducing communication stack overhead on the main application processor.
* ESP32 can interface with other systems to provide Wi-Fi and Bluetooth functionality through its SPI/SDIO or I2C/UART interface.

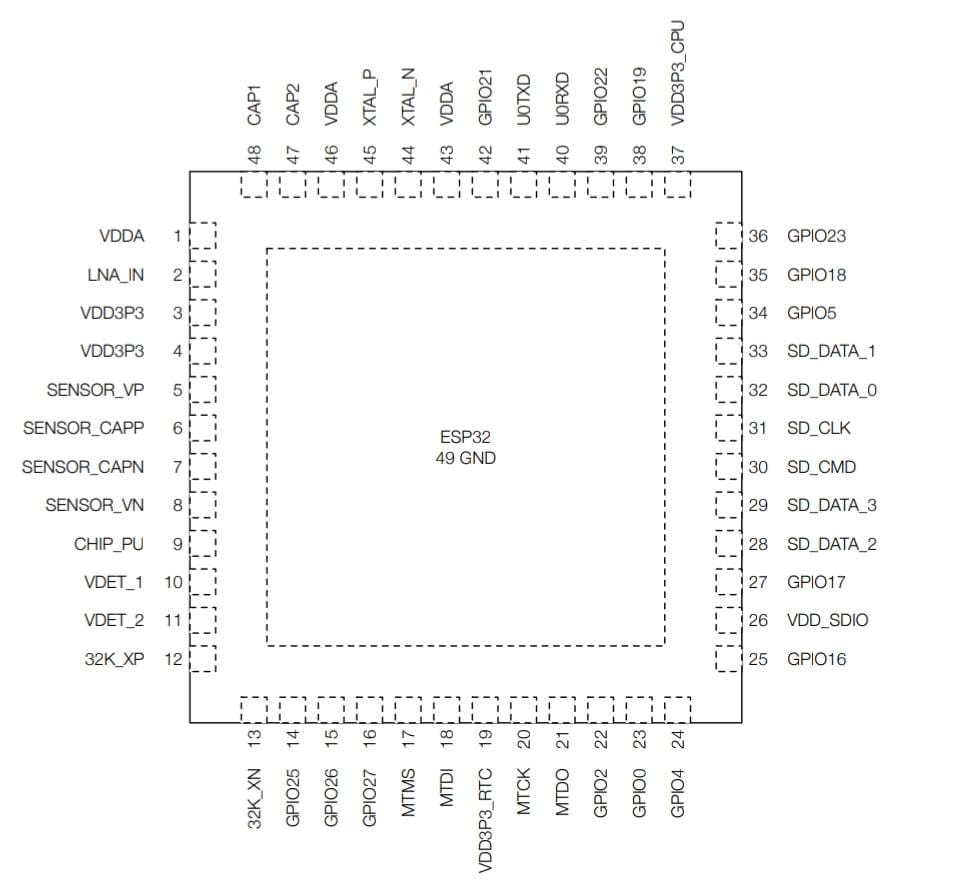


Fig 3: Architecture ESP32 Microcontroller

**PIN DESCRIPTION**

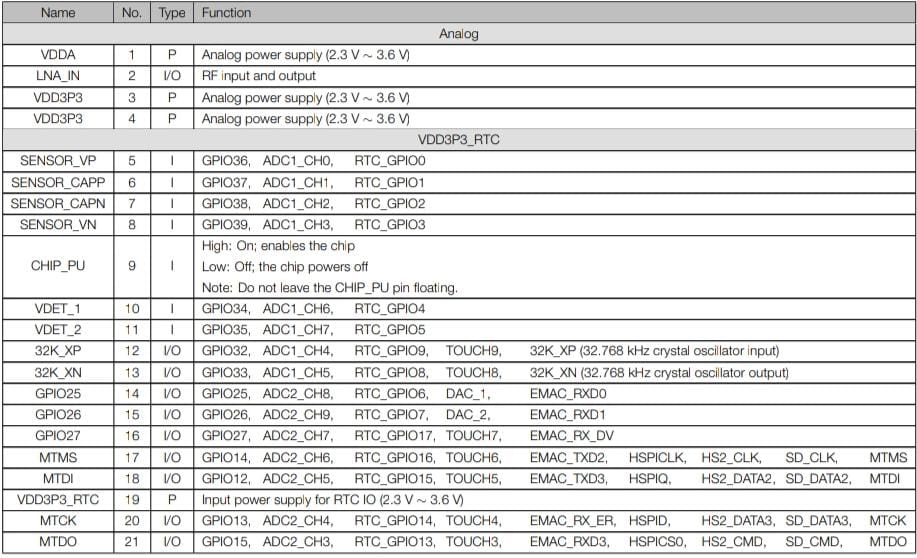
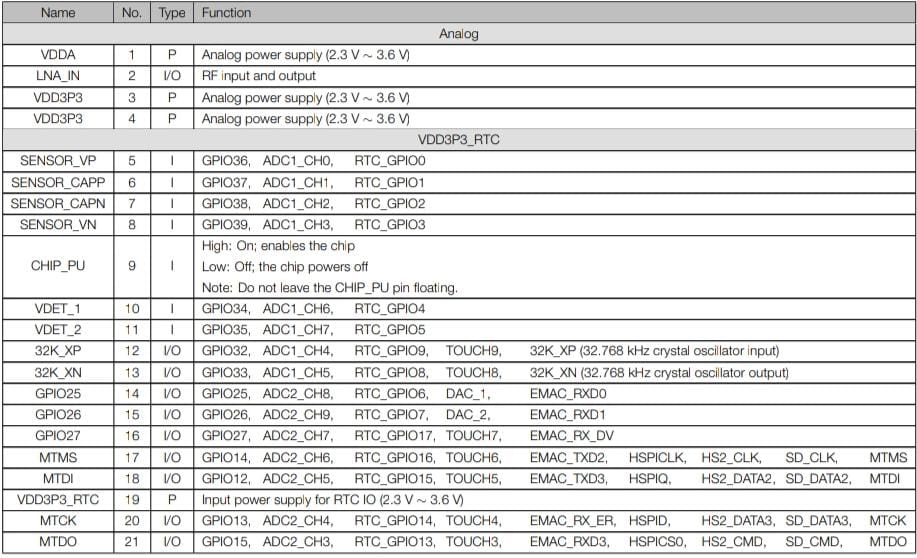


Fig.5 Pin details of ESP32 microcontroller



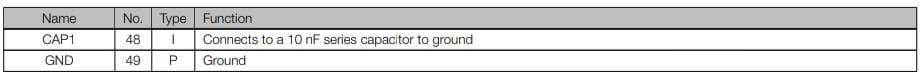


Fig 5 Pin Details of ESP32 microcontroller

**CIRCUIT DIAGRAM**

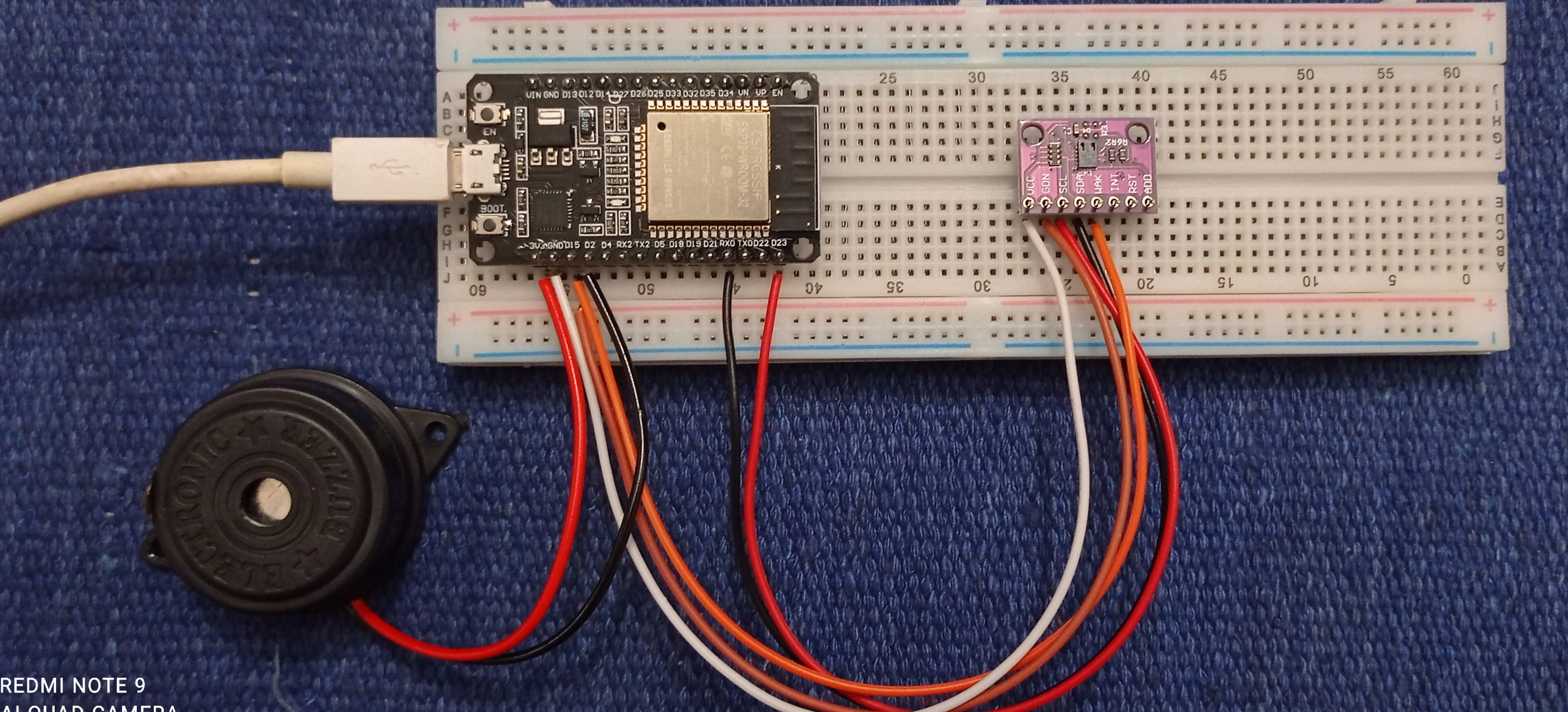
****

Fig 6 Circuit diagram

**2.CODE.**

#include <HTTP\_Method.h>

#include <Uri.h>

#include <WebServer.h>

IPAddress ip;

#include <LiquidCrystal.h>

#include <Wire.h> // I2C library

#include "ccs811.h" // CCS811 library

//const int rs = 19, en = 23, d4 = 18, d5 = 17, d6 = 16, d7 = 15;

LiquidCrystal lcd(13, 12, 14, 27, 26, 25);

#define buzzerPin 14

// Wiring for ESP8266 NodeMCU boards: VDD to 3V3, GND to GND, SDA to D2, SCL to D1, nWAKE to D3 (or GND)

CCS811 ccs811(23); // nWAKE on D3

float val1, val2;

const char\* ssid = "Project"; // Enter SSID here

const char\* password = "12345678"; //Enter Password here

WebServer server(80);

void setup()

{

// Enable serial

Serial.begin(115200);

Serial.println("");

Serial.println("setup: Starting CCS811 basic demo");

Serial.print("setup: ccs811 lib version: ");

Serial.println(CCS811\_VERSION);

// Enable I2C

Wire.begin();

// Enable CCS811

ccs811.set\_i2cdelay(50); // Needed for ESP8266 because it doesn't handle I2C clock stretch correctly

bool ok = ccs811.begin();

if ( !ok ) Serial.println("setup: CCS811 begin FAILED");

// Print CCS811 versions

Serial.print("setup: hardware version: "); Serial.println(ccs811.hardware\_version(), HEX);

Serial.print("setup: bootloader version: "); Serial.println(ccs811.bootloader\_version(), HEX);

Serial.print("setup: application version: "); Serial.println(ccs811.application\_version(), HEX);

// Start measuring

ok = ccs811.start(CCS811\_MODE\_1SEC);

if ( !ok ) Serial.println("setup: CCS811 start FAILED");

Serial.println("Connecting to ");

Serial.println(ssid);

//connect to your local wi-fi network

WiFi.begin(ssid, password);

WiFi.setSleep(false);

//check wi-fi is connected to wi-fi network

while (WiFi.status()== WL\_CONNECTED) {

delay(1000);

Serial.print(".");

}

Serial.println("");

Serial.println("WiFi connected..!");

Serial.print("Got IP: ");

ip =WiFi.localIP();

Serial.println(ip);

server.on("/", handle\_OnConnect);

server.onNotFound(handle\_NotFound);

server.begin();

Serial.println("HTTP server started");

}

void loop()

{

uint16\_t eco2, etvoc, errstat, raw;

ccs811.read(&eco2, &etvoc, &errstat, &raw);

// Print measurement results based on status

if ( errstat == CCS811\_ERRSTAT\_OK )

{

val1 = eco2;

val2 = etvoc;

if(val1>2000)

{

digitalWrite(buzzerPin,HIGH);

delay(2000);

}

if(val2>2000)

{

digitalWrite(buzzerPin,HIGH);

delay(2000);

}

Serial.print("CCS811: ");

Serial.print("eco2=");

Serial.print(val1);

Serial.print(" ppm ");

lcd.setCursor(0,0);

lcd.print("co2: ");

lcd.print(val1);

lcd.print("ppm");

delay(1000);

Serial.print("etvoc=");

Serial.print(val2);

Serial.print(" ppb ");

Serial.println();

lcd.setCursor(0,1);

lcd.print("TVOC: ");

lcd.print(val2);

lcd.print("pbm");

delay(1000);

}

else if ( errstat == CCS811\_ERRSTAT\_OK\_NODATA )

{

Serial.println("CCS811: waiting for (new) data");

} else if ( errstat & CCS811\_ERRSTAT\_I2CFAIL )

{

Serial.println("CCS811: I2C error");

}

else

{

Serial.print("CCS811: errstat=");

Serial.print(errstat, HEX);

Serial.print("=");

Serial.println( ccs811.errstat\_str(errstat) );

}

delay(1000);

server.handleClient();

}

void handle\_OnConnect()

{

server.send(200, "text/html", SendHTML(val1, val2));

}

void handle\_NotFound()

{

server.send(404, "text/plain", "Not found");

}

String SendHTML(float val1, float val2)

{

String ptr = "<!DOCTYPE html> <html>\n";

ptr += "<head><meta name=\"viewport\" content=\"width=device-width, initial-scale=1.0, user-scalable=no\">\n";

ptr += "<title>Measured Air Quality</title>\n";

ptr += "<style>html { font-family: Helvetica; display: inline-block; margin: 0px auto; text-align: center;}\n";

ptr += "body{margin-top: 50px;} h1 {color: #444444;margin: 50px auto 30px;}\n";

ptr += "p {font-size: 24px;color: #444444;margin-bottom: 10px;}\n";

ptr += "</style>\n";

ptr += "<script>\n";

ptr += "setInterval(loadDoc,1000);\n";

ptr += "function loadDoc() {\n";

ptr += "var xhttp = new XMLHttpRequest();\n";

ptr += "xhttp.onreadystatechange = function() {\n";

ptr += "if (this.readyState == 4 && this.status == 200) {\n";

ptr += "document.body.innerHTML =this.responseText}\n";

ptr += "};\n";

ptr += "xhttp.open(\"GET\", \"/\", true);\n";

ptr += "xhttp.send();\n";

ptr += "}\n";

ptr += "</script>\n";

ptr += "</head>\n";

ptr += "<body>\n";

ptr += "<div id=\"webpage\">\n";

ptr += "<h1>Measured Air Quality</h1>\n";

ptr += "<p>CO2: ";

ptr += val1;

ptr += " ppm</p>";

ptr += "<p>TVOC: ";

ptr += val2;

ptr += " ppb</p>";

ptr += "</div>\n";

ptr += "</body>\n";

ptr += "</html>\n";

return ptr;}