A
PROJECT REPORT
ON

‘IOT BASED AIR QUALITY MONITORING SYSTEM FOR SMART CITY’

SUBMITTED TO
SHIVAJI UNIVERSITY, KOLHAPUR

In Partial Fulfilment of the Requirement for the award of
BACHELORS DEGREE IN ELECTRONICS ENGINEERING

SUBMITTED BY

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UNDER THE GUIDANCE OF
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DEPARTMENT OF ELECTRONICS ENGINEERING

D. K. T. E. SOCIETY’S TEXTILE AND ENGINEERING INSTITUTE, ICHALKARANJI

(An Autonomous Institute)

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CERTIFICATE

This is to certify that the project entitled

'IOT BASED AIR QUALITY MONITORING SYSTEM FOR SMART CITY'

Is a bona-fide work of the following students

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Certificate Of Publication

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ABSTRACT

Objective of this project is to design and implement a system for air quality monitoring for smart city using Internet of Things. The model initiates from sensor devices that can sense, compute, and communicate data in a network. This study measures real-time PM2.5, temperature, humidity, Air Quality Index. Monitored data is wireless transmitted via Wi-Fi module to a server. When the sensor node reads pollutant gases composition, temperature and humidity it will be displayed on the website. The monitored data with date and time can be retrieved as a tabular data for future analysis. With implementation of this work, precautionary alerts can be given to public on the designed website to wear anti-pollution mask, change paths while transporting where the relishing air pollution ensuring high reliability. It will promote the public awareness about state of air pollution and how much important it is to reduce it. There will be news, surveys regarding pollution in different countries, different ways to reduce air pollution on the website

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1. Introduction

Air pollution has been common health concern not only for humans but also for animals, plants, oceans, aquatic life worldwide. In most of countries air quality monitoring is done manually via centrally located station. Meanwhile, many populated areas of the world lack Continuous, long term air quality measurement. To date, the Geographic coverage of air quality monitoring networks has been constrained due to the implementation cost, architecture, and individual requirements for monitoring stations. Internet of Things (IoT) has become a very popular paradigm in the modern wireless communication era. The basic idea of the IoT is the distribution of all-over “objects” or “things”, which collects and exchanges data in order to achieve a common objective by means of mutual interactions. The networked connection of these physical objects to the Internet provides access to monitored remote sensor data, so that it is possible to control the physical world from a distance.

A fundamental aspect of the Internet of Things is the integration with the Cloud infrastructure, which hosts interfaces and web-based applications that enable the communication with sensors and external systems. Therefore, the Cloud computing infrastructure might provide data access and management features, with the aim of collecting and managing data made available by smart objects. A real time monitoring of the existence and the concentration of air pollutants is necessary, in order to check air quality status and trends. By continuous real time monitoring of outdoor pollutant levels, IoT might help health departments to take the most suitable and effective decisions in case the environmental conditions become incompatible with the public health.

2. Literature Review

The problem stated is a leading issue globally due to increasing industrialization and urbanization. Pollution levels around the globe are alarming. Various system are designed for monitoring pollution level either at small or large scale[1].

A vehicle monitoring setup was designed using Arduino for an economical RFID based communication which comprises of different modules: remote monitoring unit and vehicle unit. Vehicle unit senses pollutants with RFID tag and GSM modem in its vehicle. Remote monitoring unit holds server unit where XAMPP is practiced to view content in remote area . An IOT based system for monitoring pollutants allows to upload live sensor value to the default node- red cloud that is IBM Bluemix[1].

In ZigBee technology, ZigBee transmitters and receivers are used, GPS module is used for locations for pollution level on map[4].

In Arduino based method it uses sensor devices for data, Uses ESP8266 Wi-Fi module for connection to server, Uses Node.js and Node RED for displaying data on the server side[4].

3. Organization Work Procedures

3.1 Procedural Steps

- Understanding of requirement.
- Study various journal papers, take literature survey.
- Discussion with group members, guide and get different ideas.
- Finalization of idea.

3.2 Hardware Implementation Steps

- Searching for required components and hardware.
- Calculating required specifications for components.
- Schematic and circuit diagram design.
- Purchasing the hardware.
- Testing of hardware.
- Actual hardware design.
- Burning the software and program into hardware.
- Testing the system operation.

3.3 Software Implementation Steps

- Searching for required software tools.
- Calculating data storage length for database and server.
- Design a flow graph for data.
- Subscription for cloud and database storage.
- Test a designed code.
- Debugging the test codes for hardware as well as server.
- Deploy the code on server as well as hardware.
- Final testing of whole software.

4. Proposed System

The proposed system includes Arduino software and our own hardware based transmitting monitored data to cloud based server. In detail, the following environmental parameters are collected with the aim of measuring air pollution levels: Carbon Monoxide (CO), Particulate Matter (PM2.5), Ozone(O3), Ammonia (NH3).

The hardware collects all the data uploading from sensors and transmits it to the Cloud server by using the Wi-Fi module ESP8266, which is mounted on-board serial port. Then the data is analyse in a form of air quality index

The data on the cloud server will be displayed location wise. The designed app will be hosted on the same cloud.

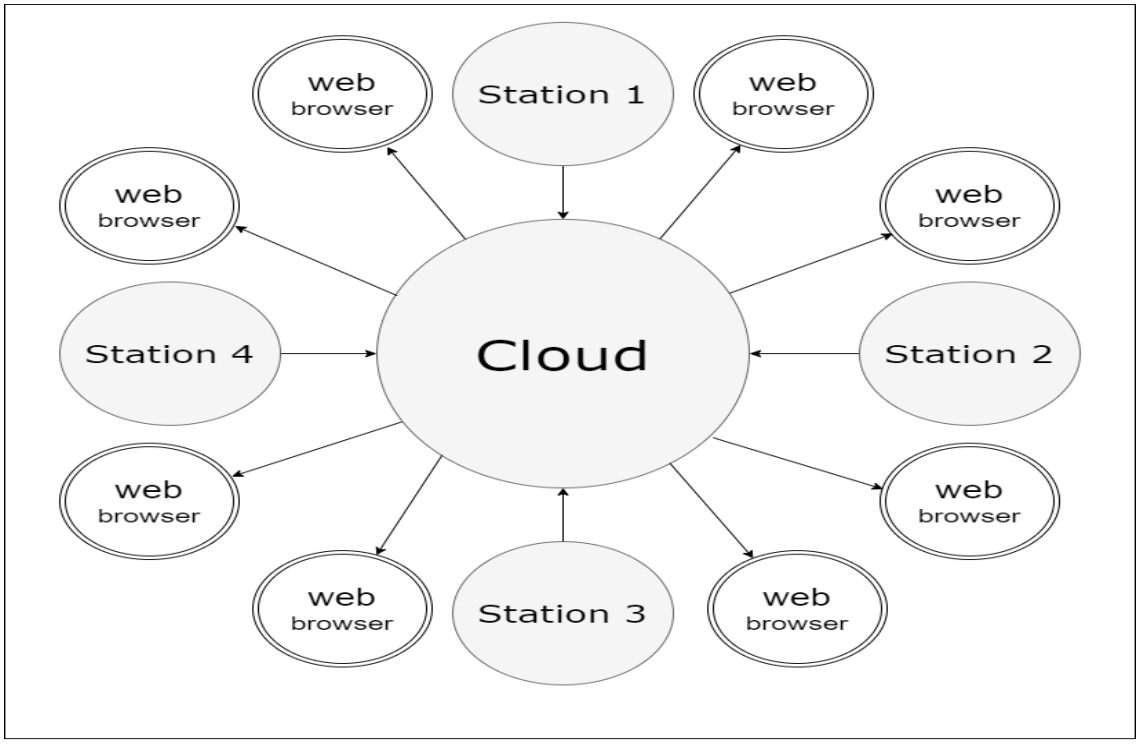


Figure 4.1: System Architecture

Arduino is an open source micro-controller which is used with other communication and sensing technologies. This single-board development environment, which allows user to read uploaded data from sensors and allows to control different devices. ESP8266 is a low cost Wi-Fi module with an AT commands library .It allows the Arduino to connect to the Internet through a Wi-Fi connection. Moreover, ESP8266 has a full TCP/IP protocol stack integrated on the chip.

There are some constraints in terms of resolution. Indeed, the inputs upload in the from analog sensors operate by default at10-bit resolution. The on/off switch in go the sensors can be operated remotely according to sensor-based data that are stored and maintained directly at the Cloud server. The Arduino collects all the data uploading from sensors and transmits it to the Cloud server by using the Wi-Fi module ESP8266,which is mounted on Arduino through an on-board serial port to air quality etc. will be updated on the website.

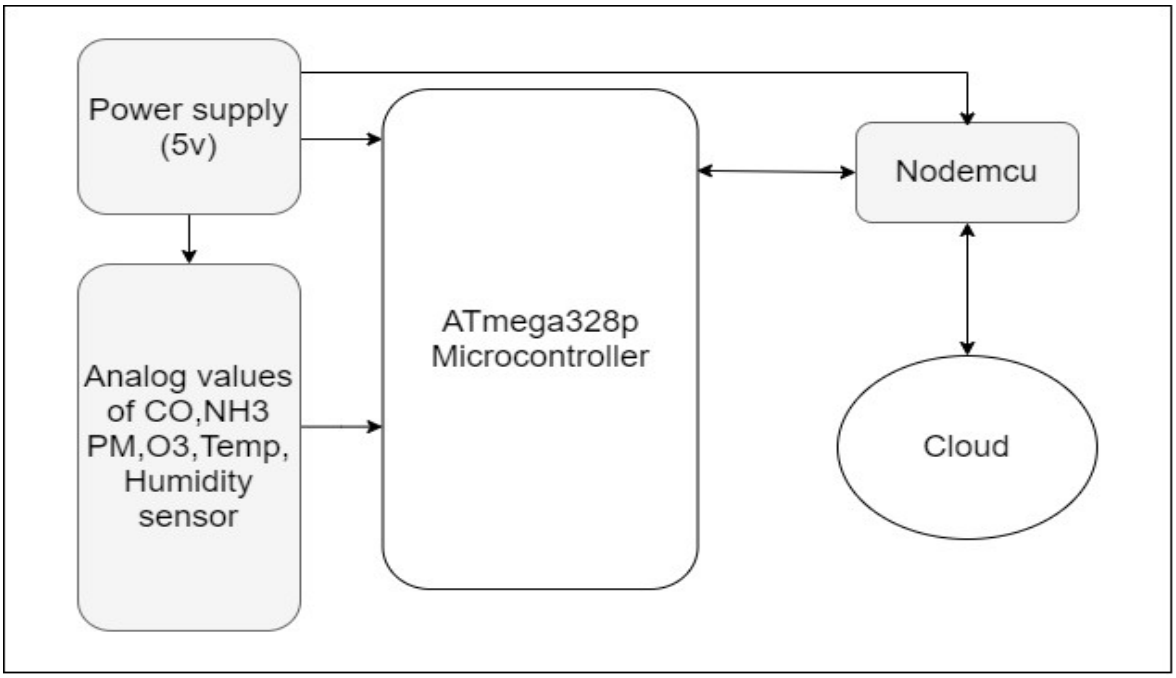


Figure 4.2: Sensor Station Block Diagram

5. Definition Of Air Quality Index

An air quality index is defined as an overall scheme that transforms the weighed values of individual air pollution related parameters (for example, pollutant concentrations) into a single number or set of numbers (Ott, 1978). The result is a set of rules (i.e. most set of equations) that translates parameter values into a more simple form by means of numerical manipulation.

If actual concentrations are reported in µg/m3 or ppm (parts per million) along with standards, then it cannot be considered as an index. At the very last step, an index in any system is to group specific concentration ranges into air quality descriptor categories.

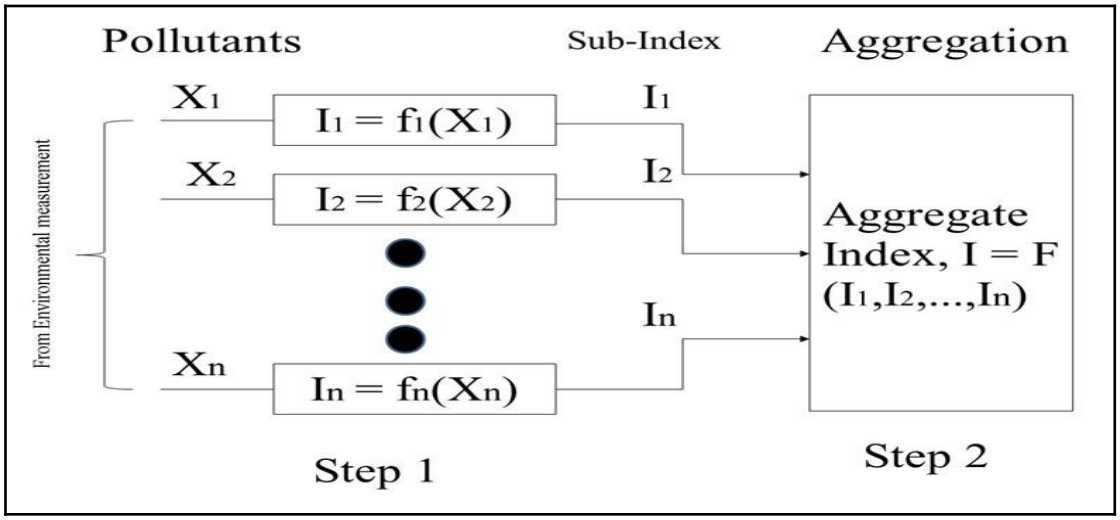


Figure 5.1: Computation Of Air Quality Index

- Structure of index

Primarily two steps are involved in formulating an AQI

(i) formation of sub-indices (for each pollutant) and

(ii) aggregation of sub-indices to get an overall AQI.

Formation of sub-indices (I1, I2,...., In) for n pollutant variables (X1, X2...., Xn) is carried out using sub-index functions that are based on air quality standards and health effects. Mathematically;

$$Ii=f(Xi), \qquad i=1, 2,...,n$$

Each sub-index represents a relationship between pollutant concentrations and health effect. The functional relationship between sub-index value (Ii) and pollutant concentrations (Xi) is explained later in the text. Aggregation of sub-indices, Ii is carried out with some mathematical function (described below) to obtain the overall index (I), referred to as AQI.

$$I=F(I1,I2,....,In)$$

Min or Max Operator (Ott 1978)

$$I = \text{Min or Max}(I1, I2, I3,..., In)$$

The revised air quality standards (CPCB, 2009) necessitate that the concept of AQI in India is examined afresh. An AQI system based on maximum operator function (selecting the maximum of sub-indices of various pollutants as overall AQI) is adopted. Ideally, eight parameters (PM2.5,CO, O3, N H3,Pb) having short-term standards should be considered for near real-time dissemination of AQI. It is recognized that air concentrations of Pb are not known in real-time and cannot contribute to AQI. However, its consideration in AQI calculation of past days will help in scrutinizing the status of this important toxic.

The proposed index has six categories and the schemes shown below.

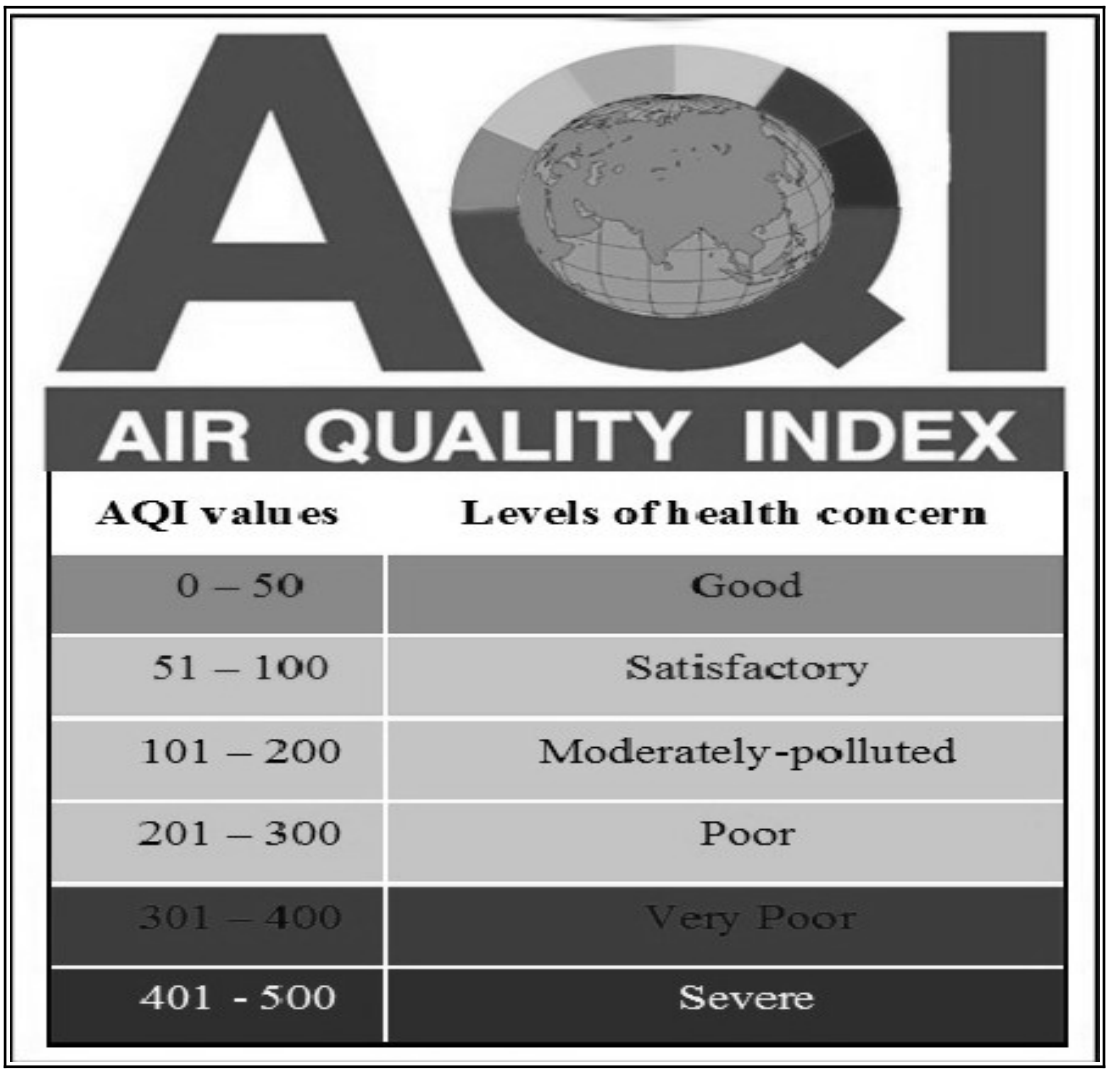


Figure 5.2: Air Quality Index Categories

QR code 5:1: For More Information About Air Quality Index

6. Hardware Design Components & Tools

Following components are used to design the hardware:

- ATmega328p.
- NodeMCU.
- MQ-7 Carbon Monoxide (CO) Sensor.
- Dust Sensor -Particulate Matter (PM2.5).
- MQ-131 Ozone(O3) Senaor.
- MQ-137 Ammonia (NH3) Sensor.
- DHT 22 Tempature and Humidity Sensor.

6.1 ATmega328p

The ATmega328 is a single-chip microcontroller created by Atmel in the megaAVR family. It has a modified Harvard architecture 8-bit RISC processor core.

6.1.1 Features

1. High Performance, Low Power Atmel®AVR® 8-Bit Microcontroller Family.
2. Advanced RISC Architecture.
    - 131 Powerful Instructions – Most Single Clock Cycle Execution.
    - 32x8 General Purpose Working Registers.
    - Up to 20 MIPS Throughput at 20MHz.
3. High Endurance Non-volatile Memory Segments.
    - 32KBytes of In-System Self-Programmable Flash program memory
    - 1KBytes EEPROM
    - 2KBytes Internal SRAM
4. Peripheral Features
    - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
    - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode

- Six PWM Channels
- 6-channel 10-bit ADC
- Programmable Serial USART
- Master/Slave SPI Serial Interface

5. Special Microcontroller Features
   - Power-on Reset
   - Internal Calibrated Oscillator
   - External and Internal Interrupt Sources
   - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
6. I/O and Packages
   - 23 Programmable I/O Lines
   - 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF
7. Operating Voltage
   - 1.8 - 5.5V
8. Temperature Range
   - -40°C to 85°C
9. Speed Grade
   - 0 - 20MHz
10. Power Consumption at 1MHz, 1.8V, 25°C
    - Active Mode: 0.2mA
    - Power-down Mode: 0.1µA
    - Power-save Mode: 0.75µA (Including 32kHz RTC)

6.1.2 Pin Descriptions

- VCC: Digital supply voltage.
- GND**:** Ground.
- Port A (PA7..PA0)**:** Port A serves as the analog inputs to the A/D Converter. Port A also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used .Port pins can provide internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins

PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

- Port B (PB7..PB0)**:** Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.
- Port C (PC7..PC0)**:** Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PC5(TDI), PC3(TMS) and PC2(TCK) will be activated even if a reset occurs. The TD0 pin is tri-stated unless TAP states that shift out data are entered.
- Port D (PD7..PD0)**:** Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.
- RESET**:** Reset Input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running.
- XTAL1**:** Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.
- XTAL2**:** Output from the inverting Oscillator amplifier.
- AVCC**:** AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter.
- AREF**:** AREF is the analog reference pin for the A/D Converter.

6.1.3 Pin Configuration

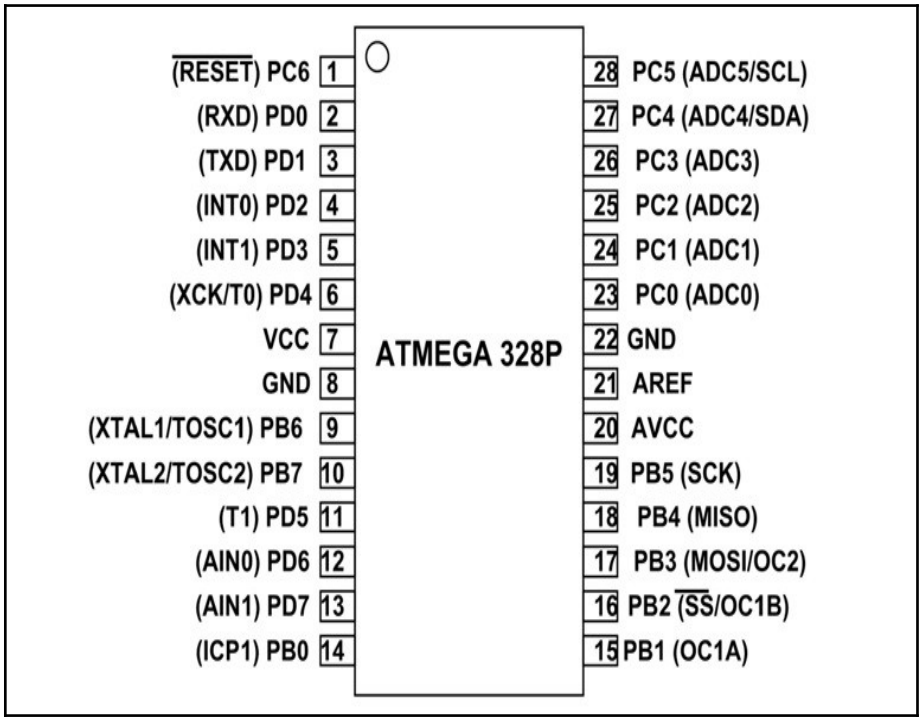


Figure 6.1: Pin Configuration of ATmega328p

QR code 6:1: For More Information About Atmega328p

6.2 NodeMCU

NodeMCU is a low-cost open source IoT platform. It initially included firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which was based on the ESP-12 module. Later, support for the ESP32 32-bit MCU was added.

6.2.1 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
- Wi-Fi: IEEE 802.11 b/g/n:
  - Integrated TR switch, balun, LNA, power amplifier and matching network
  - WEP or WPA/WPA2 authentication, or open networks

6.2.2 Pin Configuration

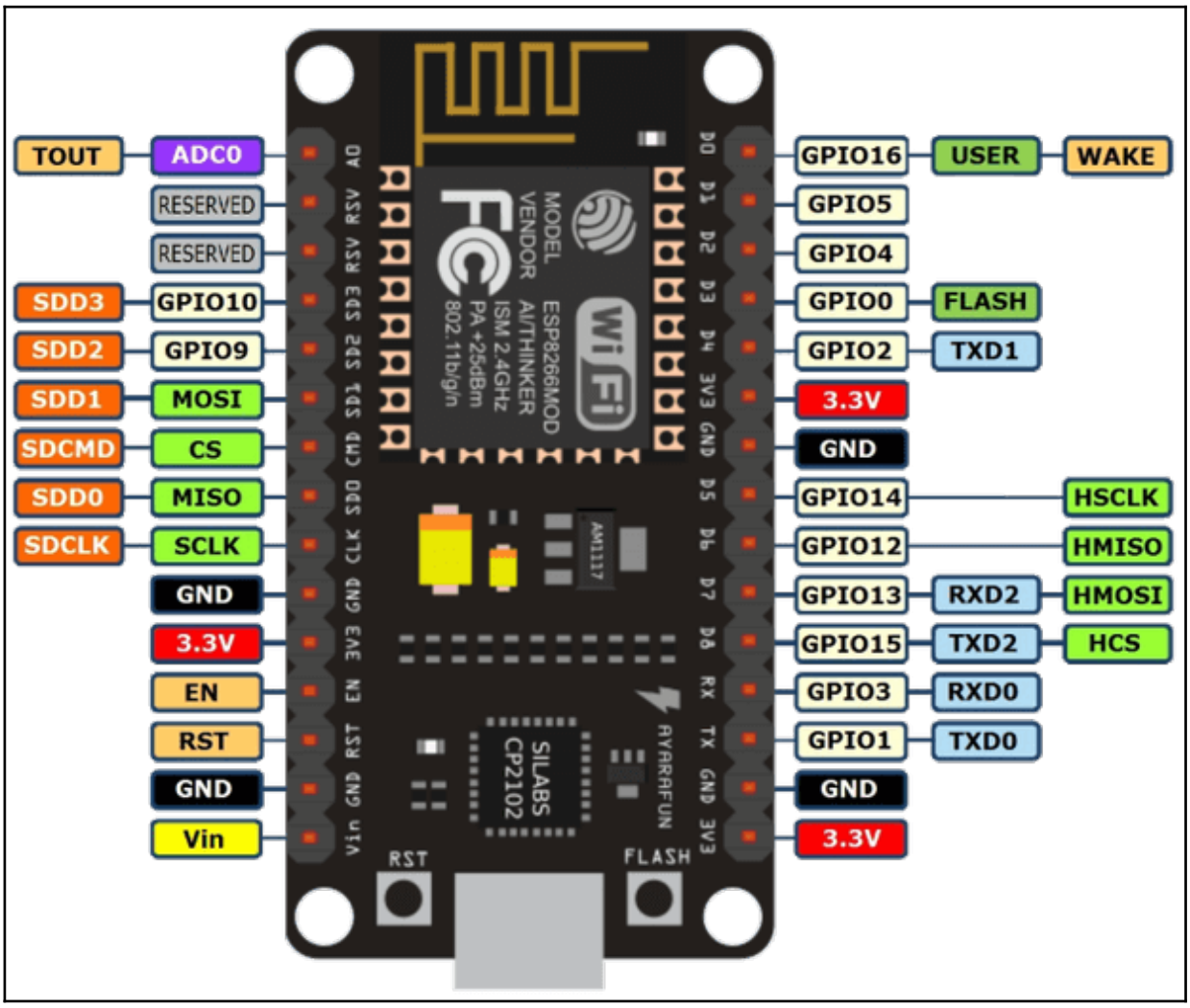


Figure 6.2: Node MCU Pin Configuration

6.2.3 Pin Description

- **GPIO(General Purpose Input Output)Pins:** NodeMCU has general purpose input output pins on its board as shown in above pinout diagram. We can make it digital high/low and control things like LED or switch on it. Also We can generate PWM signal on this GPIO pins.
- **ADC(Analog to Digital Converter)Channel(A0):** NodeMCU has ADC Channel on its board. On board resister divider network which provide 1.0V from 3.3V to ADC pin of

ESP8266. Hence ,we can use 0-3.33V range for ADC input voltage for NodeMCU Dev Kit. Since 10 bit resolution, it will give 0-1023 value range for ADC input voltage 0-3.3V on Dev Kit.

- **SPI(Serial Peripheral Interface)Pins:** NodeMCU based ESP8266 has hardware SPI with your pins available for SPI communication. It also has SPI pins for Quad-SPI communication. With this SPI interface, we can any SPI enabled device with NodeMCU and make communication possible with it.
- **I2C(Inter Integrated Circuit) Pins:** NodeMCU has I2C functionality Support on ESP8266 GPIO Pins. Due to internal functionality on ESP-12E we cannot use all its GPIO for I2C functionality.
- **UART(Universal Asynchronous Receiver Transmitter)Pins:** NodeMCU Has two UART interfaces, UART 0 and UART 1.Since UART 0(RXD0 & TXD0) is used to upload firmware / codes to board we cannot use them in applications while uploading firmware/codes

QR code 6.2: For More Information About NodeMCU

6.3 MQ-7

Sensitive material of MQ-7 gas sensor is SnO2, which with lower conductivity in clean air. It make detection by method of cycle high and low temperature, and detect CO at low temperature(heated by 1.5V).The sensor's conductivity gets higher along with the CO gas concentration rising. At high temperature(heated by 5.0V),it cleans the other gases adsorbed at low temperature. Users can convert the change of conductivity to correspond output signal of gas concentration through a simple circuit.

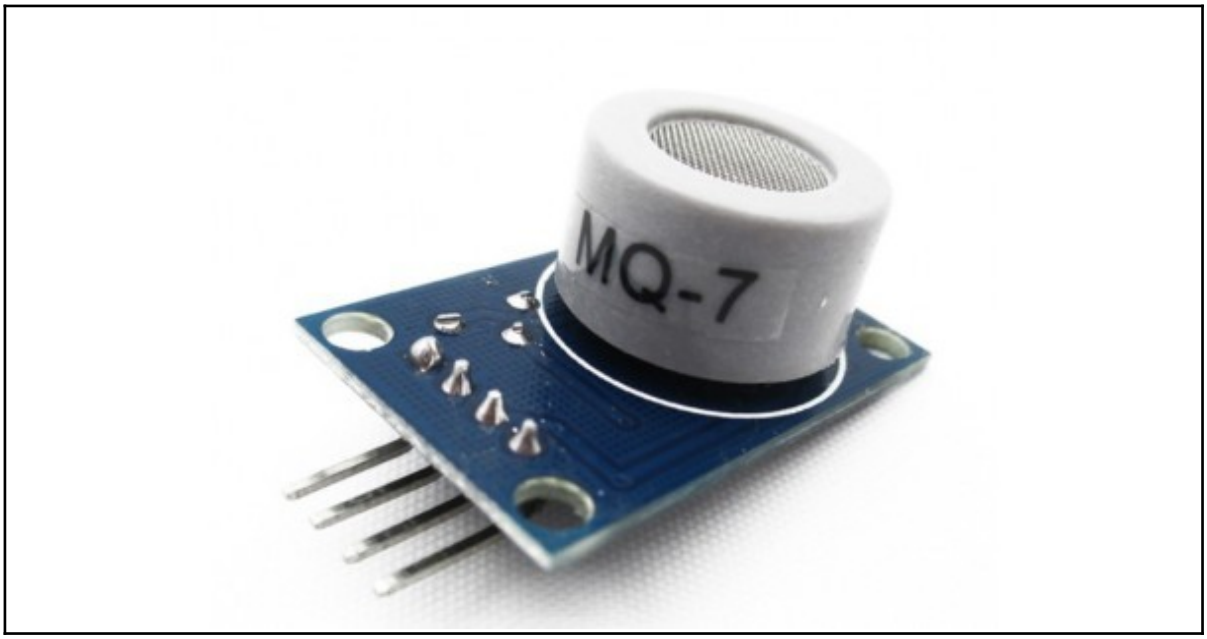


Figure 6.3: MQ-7

6.3.1 Features

- High sensitivity to carbon monoxide.
- Stable and long life.

6.3.2 Specifications

Table 6.1: Standard Work Conditions

Symbol	Parameter name	Technical Condition
Vc	Circuit Voltage	5V ± 0.1
VH	Heating voltage	5V ± 0.1
RL	Load resistance	Can adjust
RH	Heating resistance	33Ω ± 5%
TH (H)	Heating time (high)	60 ± 1 seconds
TH (L)	Heating time (low)	90 ± 1 seconds

- Detecting range: 20ppm-2000ppm carbon monoxide

Table 6.2: Environment Conditions

Symbol	Parameter Name	Technical Condition
Tao	Using temperature	-20℃-50℃
Tas	Storage temperature	-20℃-50℃
O2	Oxygen concentration	21%(stand condition) the oxygen concentration can affect the sensitivity characteristic

6.3.3 Structure & configuration

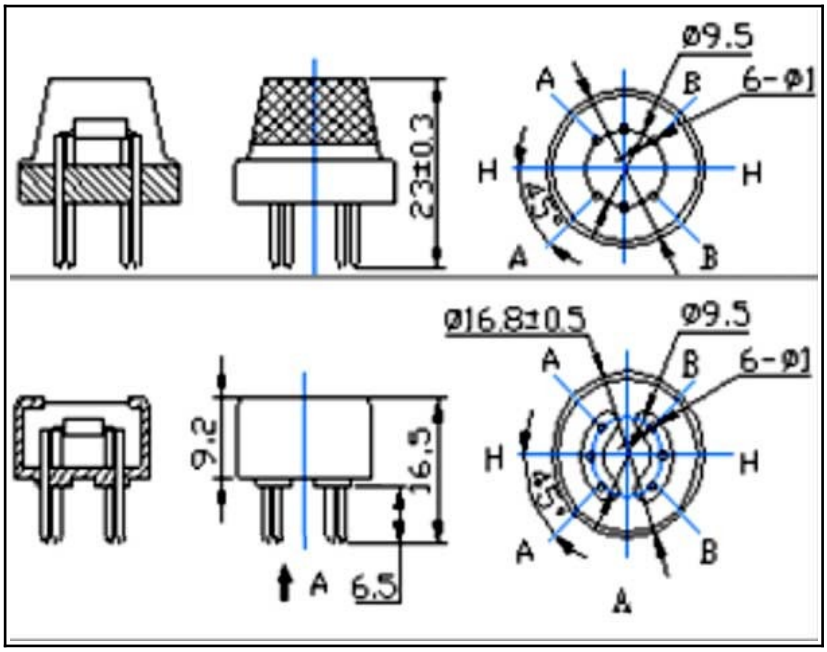


Figure 6.4: Structure diagrams

Table 6.3: Materials

Sr. No.	Parts	Materials
1	Gas sensing layer	SnO2
2	Electrode	Au
3	Heater coil	Ni-Cr alloy
4	Resin base	Bakelite
5	Clamp ring And Tube Pin	Copper plating Ni

6.3.4 Basic Structure

The above fig is the basic test circuit of MQ-7.The sensor requires two voltage inputs: heater voltage (VH) and circuit voltage(VC). VH is used to supply standard working temperature to the sensor and it can adopt DC or AC power. For this model sensor, VH should be at 1.5V±0.1V low voltage when detect CO while should be at 5V±0.1V at non detection status(resuming period). VRL is the voltage of load resistance RL which is in series with sensor. Vc supplies the detect voltage to load resistance RL and it should adopts DC power.

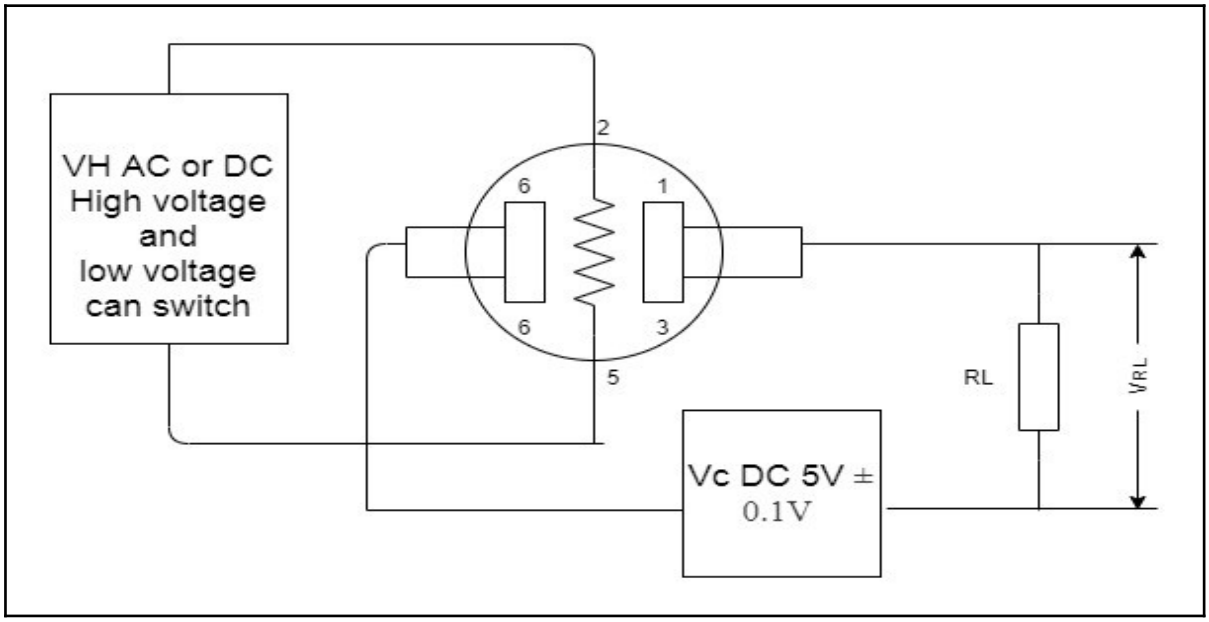


Figure 6.5: Internal Citcuit Diagram

QR code 6:3: For More Information About MQ 7

6.4 Dust Sensor-Particulate Matter PM 2.5

GP2Y1014AU is a dust sensor by optical sensing system. An infrared emitting diode (IRED) and photo transistor are diagonally arranged into this device. It detects the reflected light of dust in air. Especially, it is effective to detect very fine particle like the cigarette smoke. In addition it can distinguish smoke from house dust by pulse pattern of output voltage.

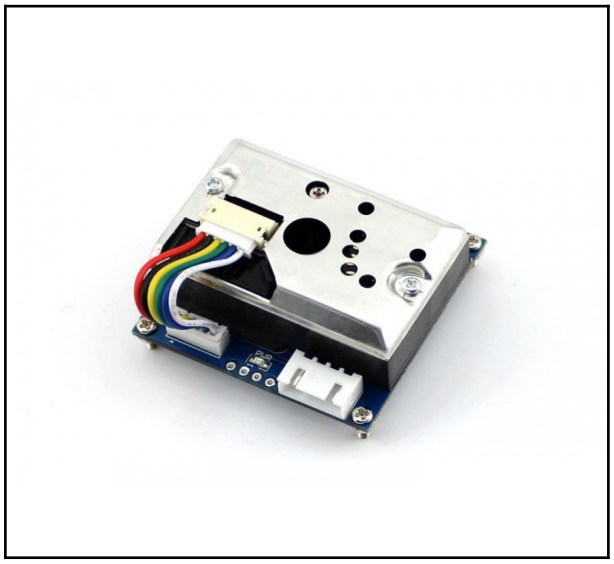


Figure 6.6: Dust Sensor

6.4.1 Specifications

- Sensitivity : 0.5V/(100µg/m3)
- Measurement range : 500µg/m3
- Power : 2.5V~5.5V
- Operating current : 20mA(max)
- Operating temperature : -10℃~65℃
- Storage temperature : -20℃~80℃
- Life time : 5 years
- Dimension : 46mm×30mm×17.6mm
- Mounting holes size : 2.0mm
- Air hole size : 9.0mm
- Enable to distinguish smoke from house dust

6.4.2 Internal Schematic of PM 2.5

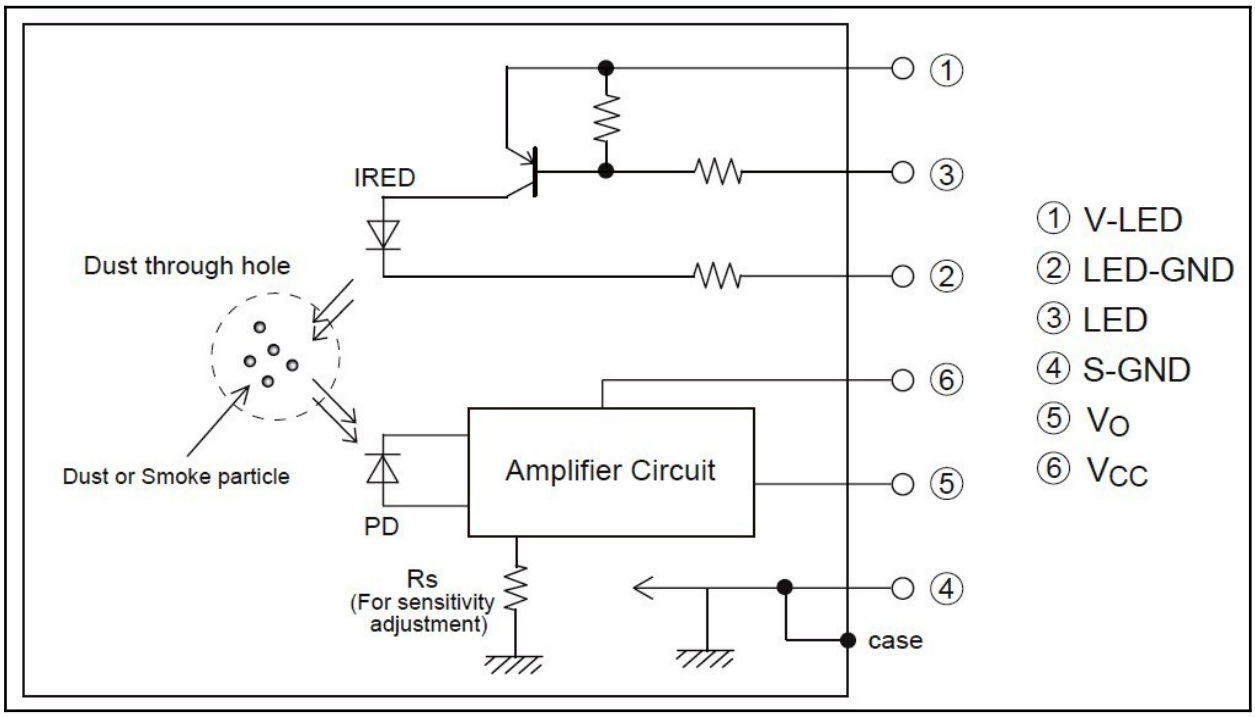


Figure 6.7: Internal Schematic of PM 2.5 Sensor

Table 6.4: Maximum Absolute Ratings

Parameter	Symbol	Rating
Supply voltage	Vcc	−0.3V to +7V
Input terminal voltage	V_{LED}	−0.3V to V_{CC}
Operating temperature	T_{OPR}	−10°C to +65°C
Soldering temperature	T_{SOL}	−20°C to +80°C

Table 6.5: Electro-Chemical Characteristics

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Sensitivity	K	*1 *2 *3	0.35	0.5	0.65	V/(0.1mg/m^3)
Output voltage at no dust	V_{OC}	*2 *3	0	0.9	1.5	V

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Output voltage range	VOH	*2 *3 RL =4.7kΩ	3.4	-	-	V
LED terminal current	ILED	*2 LED terminal voltage = 0	-	10	20	mA
Consumption current	ICC	*2 RL =∞	-	11	20	mA

*1: Sensitivity is specified by the amount of output voltage change when dust density changes by 0.1 mg/m3. And the dust density for detection is a value of the density of cigarette smoke measured by the digital dust monitor.

*2: Input Condition for LED Input Terminal

*3: Sampling Timing of Output Pulse

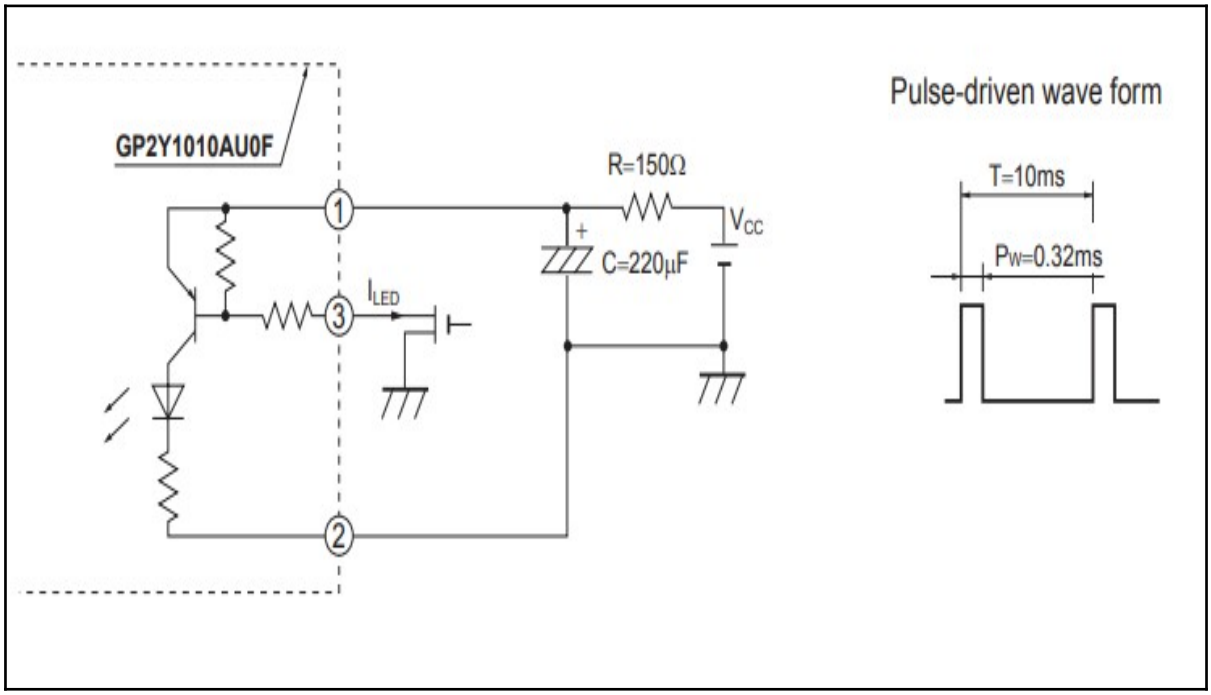


Figure 6.8: Input Condition

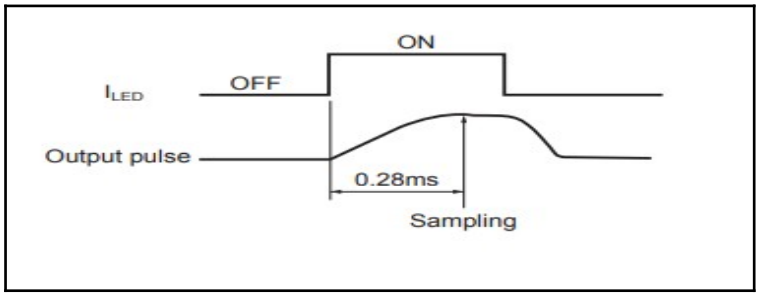


Figure 6.9: Output Sampling Time

Table 6.6: Recommended Input Condition For LED Input Terminal

Parameter	Symbol	Value	Unit
Pulse Cycle	T	10 ± 1	ms
Pulse Width	Pw	0.32 ± 0.02	ms
Operating Supply voltage	Vcc	5 ± 0.5	V

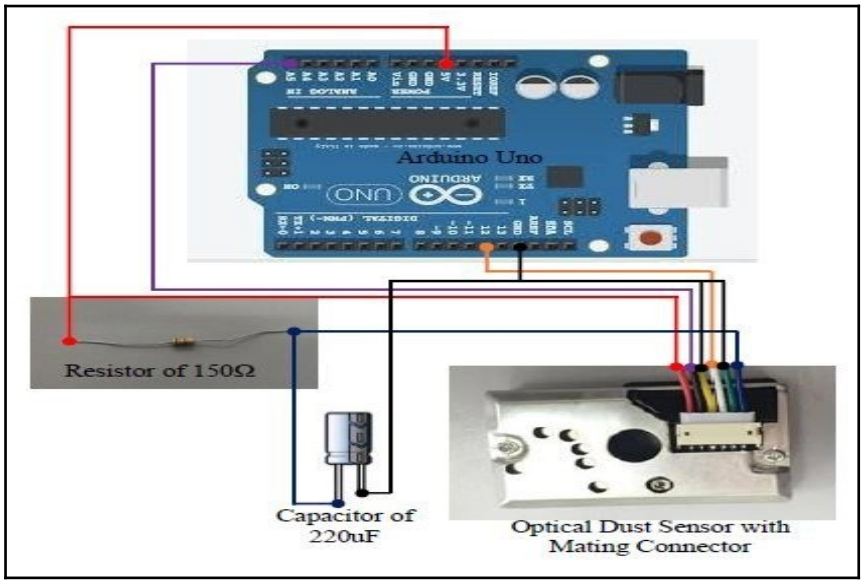


Figure 6.10: Interfacing With Arduino Board

6.4.3 Pin Description

- V-LED – Arduino 5v with 150ohm resistor in between.
- LED-GND – Arduino GND.
- LED – Arduino Digital Pin 12.
- S-GND -- Arduino GND.
- Vo -- Arduino Analog Pin 5.
- Vcc – Arduino 5v.

QR code 6:4: For More Information About Dust Sensor

6.5 MQ-131

Sensitive material of MQ131 gas sensor is semiconductor metallic oxide, which with high conductivity in clean air. When the ozone gas exists, the sensor's conductivity gets lower along with the gas concentration rising. Users can convert the change of conductivity to correspond output signal of gas concentration through a simple circuit.

MQ131 ozone gas sensor has high sensitivity to ozone, and also has sensitivity to strong oxide such as Cl2, NO2 &etc. It responses oppositely to organic interference gases.

Figure 6.11: MQ 131

6.5.1 Features

- Fast response and High sensitivity for Ozone
- Stable and long life
- Simple drive circuit
- Wide detecting range

6.5.2 Specifications

Table 6.7: Standard Work Conditions

Symbol	Parameter name	Technical Condition
Vc	Circuit Voltage	5V ± 0.1
VH	Heating voltage	6V ± 0.1
RL	Load resistance	Can adjust
RH	Heating resistance	31Ω ± 5%
PH	Heating consumption	Less than 1100mw

Table 6.8: Environment Conditions

Symbol	Parameter Name	Technical Condition
Tao	Using temperature	-10℃-50℃
Tas	Storage temperature	-20℃-70℃
RH	Related humidity	Less than 95%RH

6.5.3 Structure & Configuration

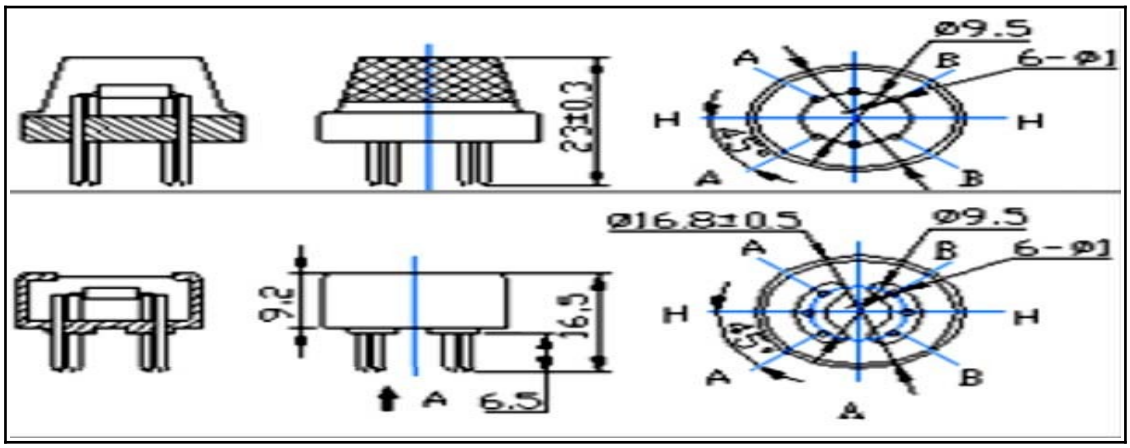


Figure 6.12: Structure diagram

Table 6.9: Materials

Sr. No.	Parts	Materials
1	Gas sensing layer	SnO2
2	Electrode	Au
3	Heater coil	Ni-Cr alloy
4	Resin base	Bakelite
5	Clamp ring And Tube Pin	Copper plating Ni

- **Detecting range:**10ppb-2ppm O3

6.5.4 Basic Circuit:

The above fig is the basic test circuit of MQ137.The sensor requires two voltage inputs: heater voltage (VH) and circuit voltage(VC). VH is used to supply standard working temperature to the sensor and it can adopt DC or AC power, while VRL is the voltage of load resistance RL which is in series with sensor. Vc supplies the detect voltage to load resistance RL and it should adopts DC power.

QR code 6:5: For More Information About MQ 131

6.6 MQ-137

Sensitive material of MQ137 gas sensor is SnO2, which with lower conductivity in clean air. When NH3 gas exists, the sensor's conductivity gets higher along with the gas concentration rising. Users can convert the change of conductivity to correspond output signal of gas concentration through a simple circuit.

MQ137 gas sensor has high sensitivity to NH3 gas, also can monitor organic amine such as trimethylamine, cholamine well. It can detect kinds of gases including ammonia and is a kind of low-cost sensor for kinds of applications.

Figure 6.13: MQ 137

6.6.1 Features

- Fast response and High sensitivity for Ammonia

- Stable and long life
- Simple drive circuit

6.6.2 Specifications

Table 6.10: Standard Work Conditions

Symbol	Parameter name	Technical Condition
Vc	Circuit Voltage	5V ± 0.1
VH	Heating voltage	5V ± 0.1
RL	Load resistance	Can adjust
RH	Heating resistance	31Ω ± 5%
PH	Heating consumption	Less than 800mw

Table 6.11: Environment Conditions

Symbol	Parameter Name	Technical Condition
Tao	Using temperature	-10℃-45℃
Tas	Storage temperature	-20℃-50℃
O2	Oxygen concentration	21%(stand condition) the oxygen concentration can affect the sensitivity characteristic

- **Detecting range:** 5-200ppm NH3

6.6.3 Structure and configuration:

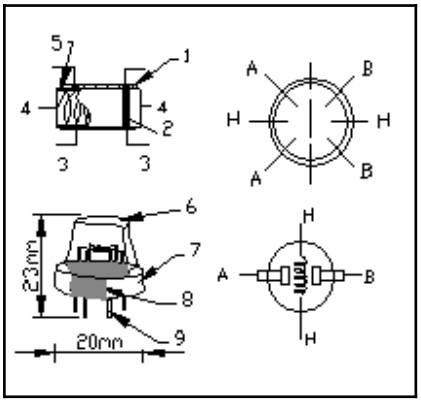


Figure 6.14: Structure Diagram

Structure and configuration of MQ-137 gas sensor is shown as Fig., sensor composed by micro ceramic tube, sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-137 have 6 pins, 4 of them are used to fetch signals, and other 2 are used for providing heating current.

Table 6.12: Materials

Sr. No.	Parts	Materials
1	Gas sensing layer	SnO2
2	Electrode	Au
3	Heater coil	Ni-Cr alloy
4	Resin base	Bakelite
5	Clamp ring And Tube Pin	Copper plating Ni

6.6.4 Basic Circuit:

The above fig is the basic test circuit of MQ137.The sensor requires two voltage inputs: heater voltage (VH) and circuit voltage(VC). VH is used to supply standard working temperature to the sensor and it can adopt DC or AC power, while VRL is the voltage of load resistance RL which is in series with sensor. Vc supplies the detect voltage to load resistance RL and it should adopts DC power.

QR code 6:6: For More Information About MQ 137

6.7 DHT22

DHT22 output calibrated digital signal. It utilizes exclusive digital-signal-collecting-technique and humidity sensing technology, assuring its reliability and stability.Its sensing elements is connected with 8-bit single-chip computer.

Every sensor of this model is temperature compensated and calibrated in accurate calibration chamber and the calibration-coefficient is saved in type of programme in OTP memory, when the sensor is detecting, it will cite coefficient from memory.

Small size & low consumption & long transmission distance(20m) enable DHT22 to be suited in all kinds of harsh application occasions.

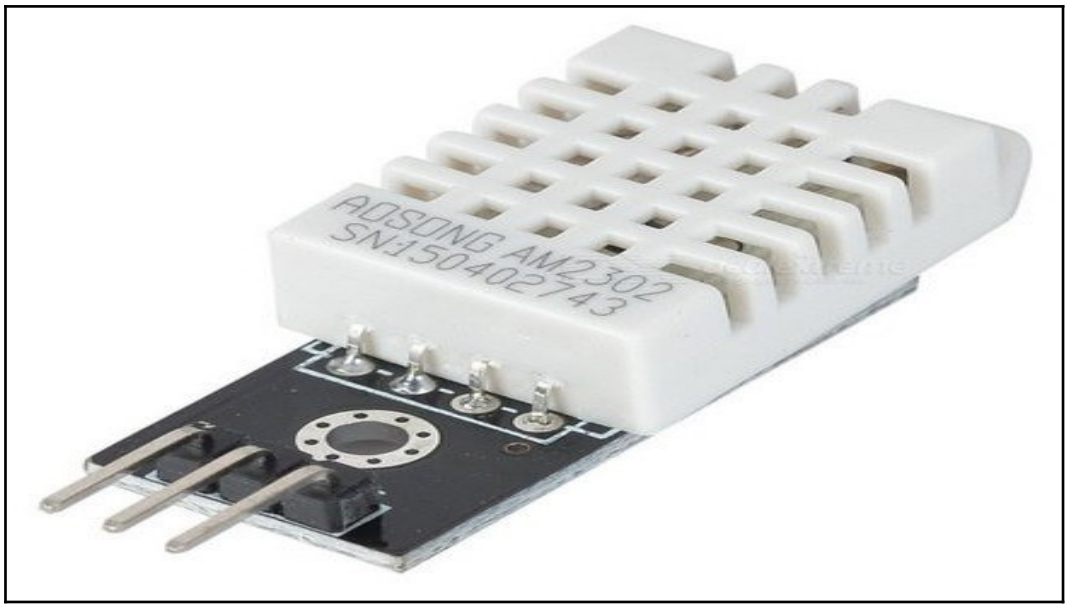


Figure 6.15: DHT 22

6.7.1 Features

- Full range temperature compensated
- Relative humidity and temperature measurement
- Calibrated digital signal
- Outstanding long-term stability
- Extra components not needed
- Long transmission distance
- Low power consumption

6.7.2 Specifications

- Operating Voltage: 3.5V to 5.5
- Operating current: 0.3mA (measuring) 60uA (standby)
- Output: Serial data
- Temperature Range: -40°C to 80°C
- Humidity Range: 0% to 100%
- Resolution: Temperature and Humidity both are 16-bit
- Accuracy: ±0.5°C and ±1%
- Dimensions- 14*18*5.5mm
- Sampling rate: 0.5Hz every 2 second
- Humidity sensor- Polymer humidity capacitor
- Temperature sensor- Thermistor

6.7.3 Working Principle

Inside the case, on the sensing side, there is a humidity sensing component along with a NTC temperature sensor (or thermistor).

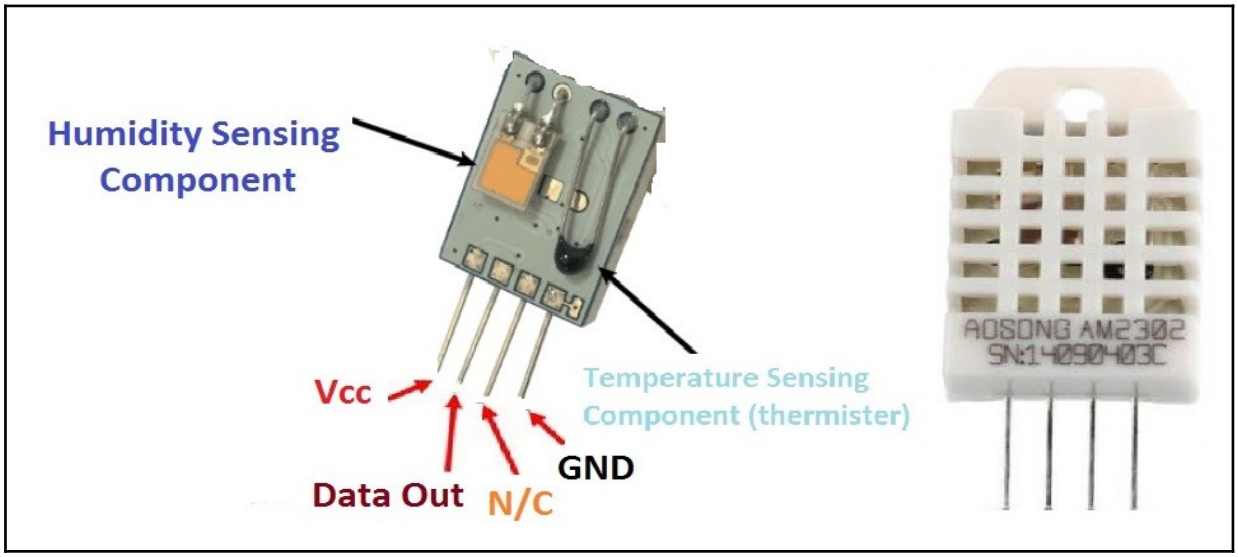


Figure 6.16: Internal Sensing Components

Humidity sensing component is used, of course to measure humidity, which has two electrodes with moisture holding substrate (usually a salt or conductive plastic polymer) sandwiched between them. The ions are released by the substrate as water vapor is absorbed by it, which in turn increases the conductivity between the electrodes. The change in resistance between the two electrodes is proportional to the relative humidity. Higher relative humidity decreases the resistance between the electrodes, while lower relative humidity increases the resistance between the electrodes.

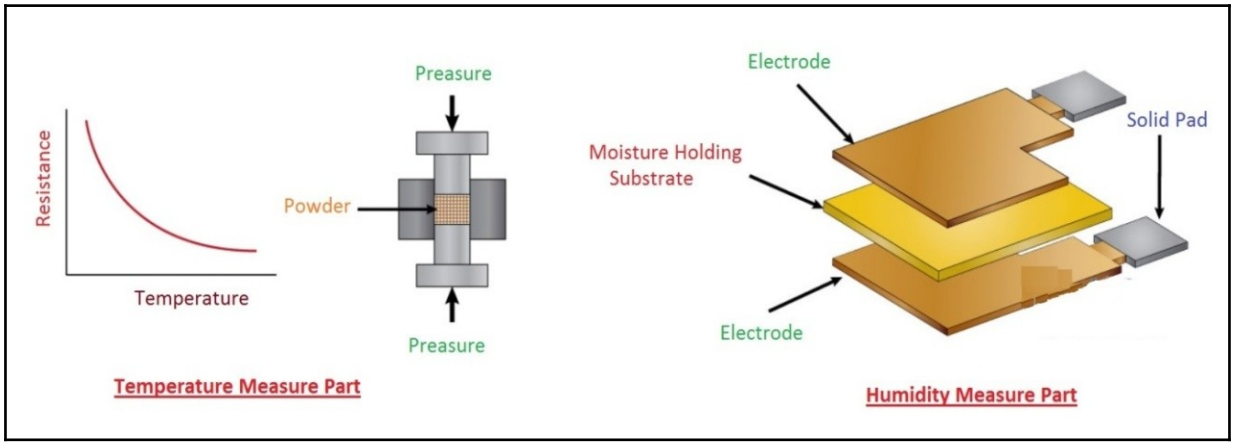


Figure 6.17: Working Principle

Besides, they consist of a NTC temperature sensor/Thermistor to measure temperature. A thermistor is a thermal resistor – a resistor that changes its resistance with temperature. Technically, all resistors are thermistors – their resistance changes slightly with temperature – but the change is usually very small and difficult to measure.

Thermistors are made so that the resistance changes drastically with temperature so that it can be 100 ohms or more of change per degree! The term “NTC” means “Negative Temperature Coefficient”, which means that the resistance decreases with increase of the temperature.

On the other side, there is a small PCB with an 8-bit SOIC-14 packaged IC. This IC measures and processes the analog signal with stored calibration coefficients, does analog to digital conversion and spits out a digital signal with the temperature and humidity.

QR code 6:7: For More Information About DHT22

6.8 PCB Designing Tool

EasyEDA is a web-based EDA tool suite that enables hardware engineers to design, simulate, share - publicly and privately - and discuss schematics, simulations and printed circuit boards. Other features include the creation of a bill of materials, Gerber files and pick and place files and documentary outputs in PDF, PNG and SVG formats.

EasyEDA allows the creation and editing of schematic diagrams, SPICE simulation of mixed analogue and digital circuits and the creation and editing of printed circuit board layouts and, optionally, the manufacture of printed circuit boards.

Subscription-free membership is offered for public plus a limited number of private projects. The number of private projects can be increased by contributing high quality public projects, schematic symbols, and PCB footprints and/or by paying a monthly subscription.

Registered users can download Gerber files from the tool free of charge but for a fee, EasyEDA offers a PCB fabrication service. This service is also able to accept Gerber file inputs from third party tools.

- **Developer(s):** EasyEDA
- **Initial release:** August 2013
- **Stable release:** 4.7.6/2017
- **Platform:** Linux, macOS, windows
- **Type:** EDA Software
- **License:** Commercial Software

QR code 6:8: For More Information About EasyEDA

7. Software Design Tools

Following programming languages and tools are used to design the software:-

- PHP.
- MySQL.
- HTML.
- Arduino IDE.
- Google Maps
- Github.
- Heroku cloud.
- Database.

7.1 PHP

PHP is a popular general-purpose scripting language that is especially suited to web development. It was originally created by Rasmus Lerdorf in 1994; the PHP reference implementation is now produced by The PHP Group. PHP originally stood for Personal Home Page, but it now stands for the recursive initialism PHP: Hypertext Preprocessor. PHP code is usually processed on a web server by a PHP interpreter implemented as a module, a daemon or as a Common Gateway Interface executable. On a web server, the result of the interpreted and executed PHP code – which may be any type of data, such as generated HTML or binary image data – would form the whole or part of a HTTP response. Various web template systems, web content management systems, and web frameworks exist which can be employed to orchestrate or facilitate the generation of that response.

- **Paradigm:** Imperative, functional, object-oriented, procedural, reflective.
- **Designed by:** Rasmus Lerdorf
- **Developer:** The PHP Development Team, Zend Technologies
- **First appeared:** 1995
- **Typing discipline:** Dynamic, weak since version 7.0: Gradual
- **Implementation language:** C (primarily, some components C++)

- **OS:** UNIX-like, Windows
- **License:** PHP License (most of Zend engine under Zend Engine License)
- **Filename extensions:** php.phtml.php3.php4.php5.php7.phps.php-s.pht.phar

7.2 MYSQL

MySQL is an open-source relational database management system. Its name is a combination of “My”, the name of co-founders Michael Widenius's daughter, and "SQL", the abbreviation for Structured Query Language. MySQL is free and open-source software under the terms of the GNU General Public License, and is also available under a variety of proprietary licenses. MySQL was owned and sponsored by the Swedish company MySQL AB, which was bought by Sun Microsystems. In 2010, when Oracle acquired Sun, Widenius forked the open-source MySQL project to create MariaDB. MySQL is a component of the LAMP web application software stack, which is an acronym for Linux, Apache, MySQL, Perl/PHP/Python. MySQL is used by many database-driven web applications, including Drupal, Joomla, phpBB, and WordPress. MySQL is also used by many popular websites, including Facebook, Flickr, MediaWiki, Twitter, and YouTube.

- **Original author(s):** MySQL AB
- **Developer(s):** Oracle Corporation
- **Initial release:** May 23, 1995
- **Written in:** C, C++
- **Operating system:** Linux, Solaris, macOS, Windows, FreeBSD
- **Available in:** English
- **Type:** RDBMS
- **License:** GPLv2 or proprietary

7.3 HTML

Hypertext Markup Language is the standard markup language for documents designed to be displayed in a web browser. It can be assisted by technologies such as Cascading

Style Sheets and scripting languages such as JavaScript. Web browsers receive HTML documents from a web server or from local storage and render the documents into multimedia web pages. HTML describes the structure of a web page semantically and originally included cues for the appearance of the document. HTML elements are the building blocks of HTML pages. With HTML constructs, images and other objects such as interactive forms may be embedded into the rendered page. HTML provides a means to create structured documents by denoting structural semantics for text such as headings, paragraphs, lists, links, quotes and other items. HTML elements are delineated by tags, written using angle brackets. Tags such as and directly introduce content into the page.

- **Filename extension:** html.htm
- **Internet media type:** text/html
- **Type code**: TEXT
- **Developed by:** WHATWG
- **Initial release:** 1993
- **Type of format:** Document file format
- **Extended from:** SGML
- **Extended to:** XHTML
- **Standards:** HTML Living Standard
- **Open format:** Yes

7.4 Arduino IDE

The Arduino Integrated Development Environment is a cross-platform application that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards. The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the

sketch and the main program loop, that are compiled and linked with a program stub main into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution.

- **Developer(s):** Arduino Software
- **Written in:** C, C++, Java
- **Operating system:** Windows, macOS, Linux
- **Platform:** IA-32, x86-64, ARM
- **Type:** Integrated development environment
- **License:** LGPL or GPL license

7.5 Goolgle Maps

Google Maps is a web mapping service developed by Google. It offers satellite imagery, aerial photography, street maps, 360° interactive panoramic views of streets, real-time traffic conditions, and route planning for traveling by foot, car, bicycle and air, or public transportation. In 2020, Google Maps was used by over 1 billion people every month. Google Maps began as a C++ desktop program at Where 2 Technologies. In October 2004, the company was acquired by Google, which converted it into a web application. After additional acquisitions of a geospatial data visualization company and a realtime traffic analyzer, Google Maps was launched in February 2005. The service's front end utilizes JavaScript, XML, and Ajax. Google Maps offers an API that allows maps to be embedded on third-party websites, and offers a locator for businesses and other organizations in numerous countries around the world.

- **Type of site:** Web mapping
- **Available in:** Multilingual
- **Owner:** Google LLC
- **Commercial:** Yes
- **Registration:** Optional, included with a Google Account
- **Launched:** February 8, 2005
- **Current status:** Active

- **Written in:** C++ (back-end), JavaScript, XML, Ajax (UI)

7.6 GitHub

GitHub, Inc. is a United States-based global company that provides hosting for software development version control using Git. It is a subsidiary of Microsoft, which acquired the company in 2018 for US$7.5 billion. It offers the distributed version control and source code management functionality of Git, plus its own features. It provides access control and several collaboration features such as bug tracking, feature requests, task management, and wikis for every project. GitHub offers plans free of charge, and professional and enterprise accounts. Free GitHub accounts are commonly used to host open source projects. As of January 2019, GitHub offers unlimited private repositories to all plans, including free accounts. As of January 2020, GitHub reports having over 40 million users and more than 100 million repositories, making it the largest host of source code in the world.

- **Type of business:** Subsidiary
- **Type of site:** Collaborative version control
- **Available in:** English
- **Founded:** February 8, 2008 (as Logical Awesome LLC)
- **Area served:** Worldwide
- **Founder(s):** Tom Preston-Werner, Chris Wanstrath, P. J. Hyett, Scott Chacon
- **CEO:** Nat Friedman
- **Key people:** Erica Brescia (COO), Carrie Olesen (CHRO), Mike Taylor (CFO)
- **Industry:** Software
- **Employees:** 1079
- **Parent:** Microsoft
- **Alexa rank:** 80 (January 13, 2020)
- **Registration:** Optional (required for creating and joining projects)
- **Users:** 40 million (Aug 2019)
- **Launched:** April 10, 2008
- **Current status:** Active

- **Written in:** Ruby

7.7 Heroku Cloud

Heroku is a cloud platform as a service supporting several programming languages. One of the first cloud platforms, Heroku has been in development since June 2007, when it supported only the Ruby programming language, but now supports Java, Node.js, Scala, Clojure, Python, PHP, and Go. For this reason, Heroku is said to be a polyglot platform as it has features for a developer to build, run and scale applications in a similar manner across most languages. Heroku was acquired by Salesforce.com in 2010 for $212 million.

- **Type:** Subsidiary
- **Industry:** Cloud platform as a service
- **Founded:** 2007
- **Founder:** James Lindenbaum, Adam Wiggins, Orion Henry
- **Key people:** Tod Nielsen (Former CEO)
- **Products:** Heroku Platform, Heroku Postgres, Heroku Redis, Heroku Enterprise, Heroku Teams, Heroku Connect, Heroku Elements
- **Parent:** Salesforce.com

7.8 Database

A database is an organized collection of data, generally stored and accessed electronically from a computer system. Where databases are more complex they are often developed using formal design and modeling techniques. The database management system is the software that interacts with end users, applications, and the database itself to capture and analyze the data. The DBMS software additionally encompasses the core facilities provided to administer the database. The sum total of the database, the DBMS and the associated applications can be referred to as a "database system". Often the term "database" is also used to loosely refer to any of the DBMS, the database system or an application associated with the

database. Computer scientists may classify database-management systems according to the database models that they support. Relational databases became dominant in the 1980s.

8. Hardware Implementation

8.1 PCB Design

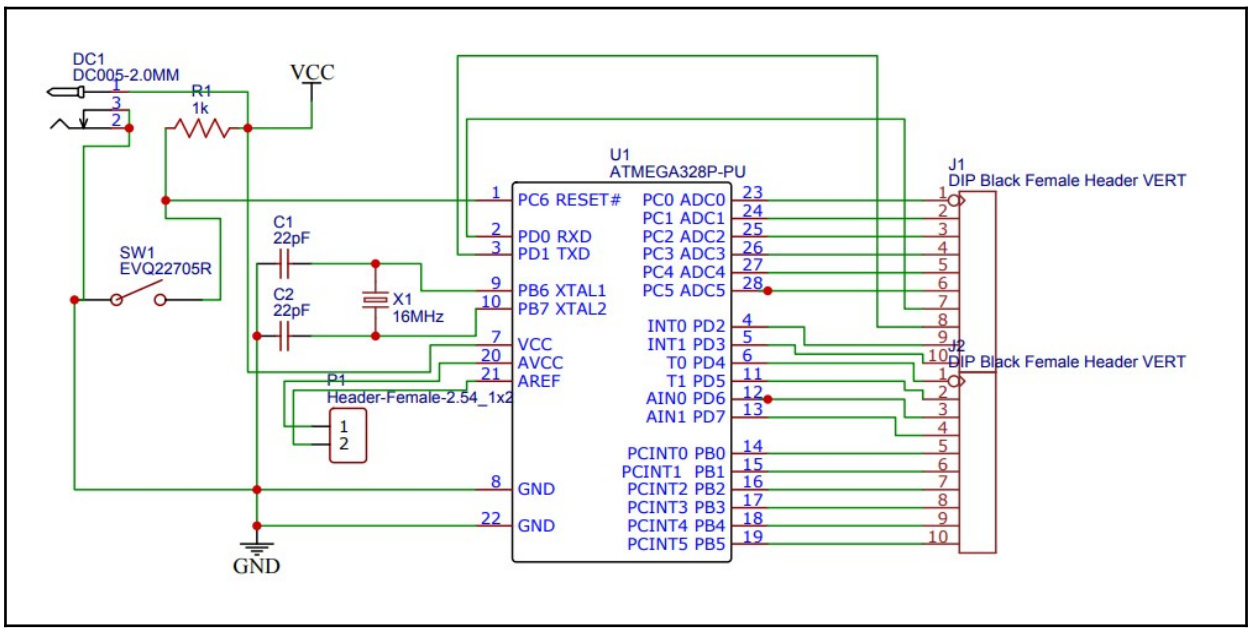


Figure 8.1: PCB Schematic

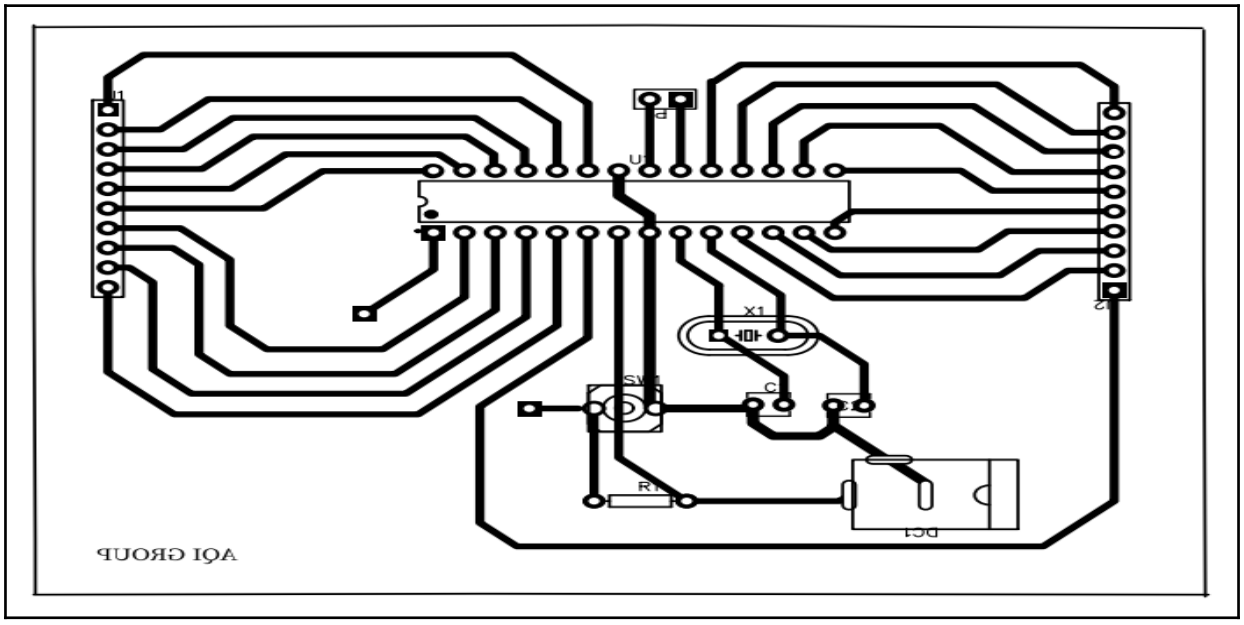


Figure 8.2: PCB Design Layout

8.2 Compatible Arduino IDE With Designed Board

If you have a new ATmega328 , you'll need to burn the bootloader onto it. You can do this using an Arduino board as an in-system program (ISP). To burn the bootloader, follow these steps:

- Upload the ArduinoISP sketch onto your Arduino board. (You'll need to select the board and serial port from the Tools menu that correspond to your board.)
- Wire up the Arduino board and microcontroller as shown in the diagram to the below.

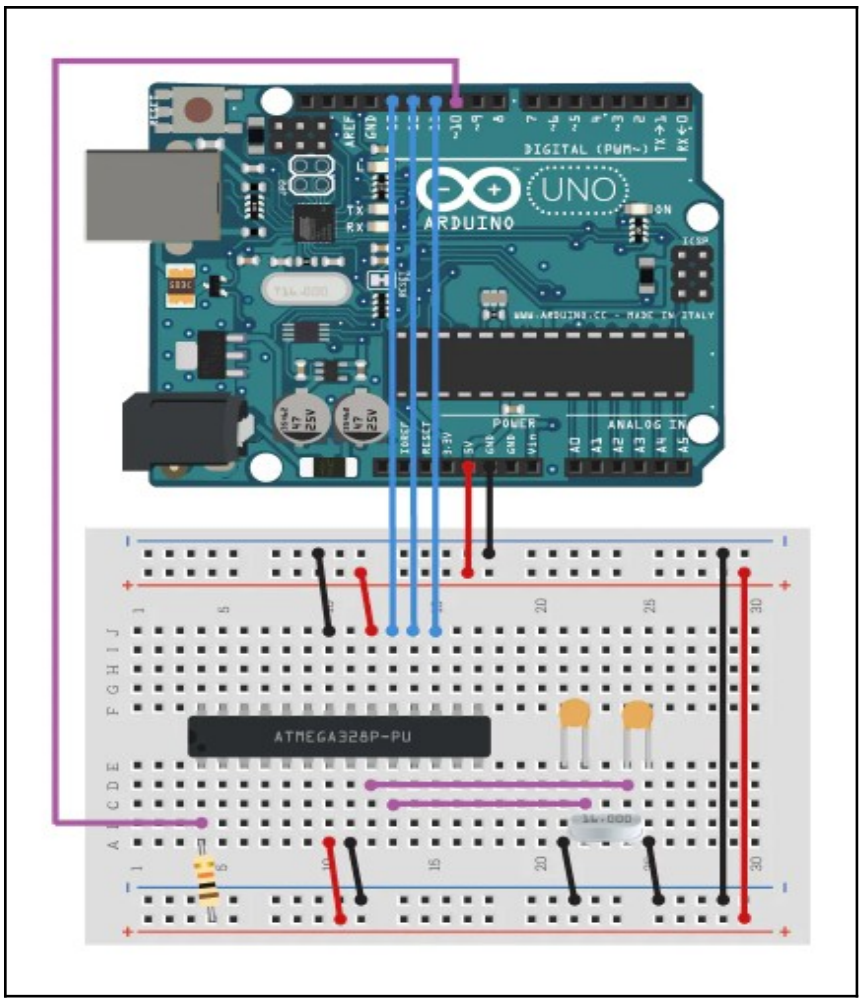


Figure 8.3: Make ATmega328p Compatible With Arduino IDE

The resistor is there to ensure that the voltage on the reset pin is high whenever it's not active. This prevents the device from randomly resetting whenever there's noise on the pin. The clock and capacitors are there to provide the chip with crucial timing information. While it's possible to load the boot loader without these components (instead relying on the chip's internal 16 MHz clock), you'll run into fewer problem if you include them.

- Select "ATmega328" from the Tools > Board menu. "ATmega328 on a breadboard (16 MHz internal clock).
- Select "Arduino as ISP" from Tools > Programmer
- Run Tools > Burn Bootloader

QR code 8:1: For More Inforation About Arduino

9. Software Implementation

9.1 Station-side Software

In the station software we use Arduino IDE which is based on C & C++ programming language.

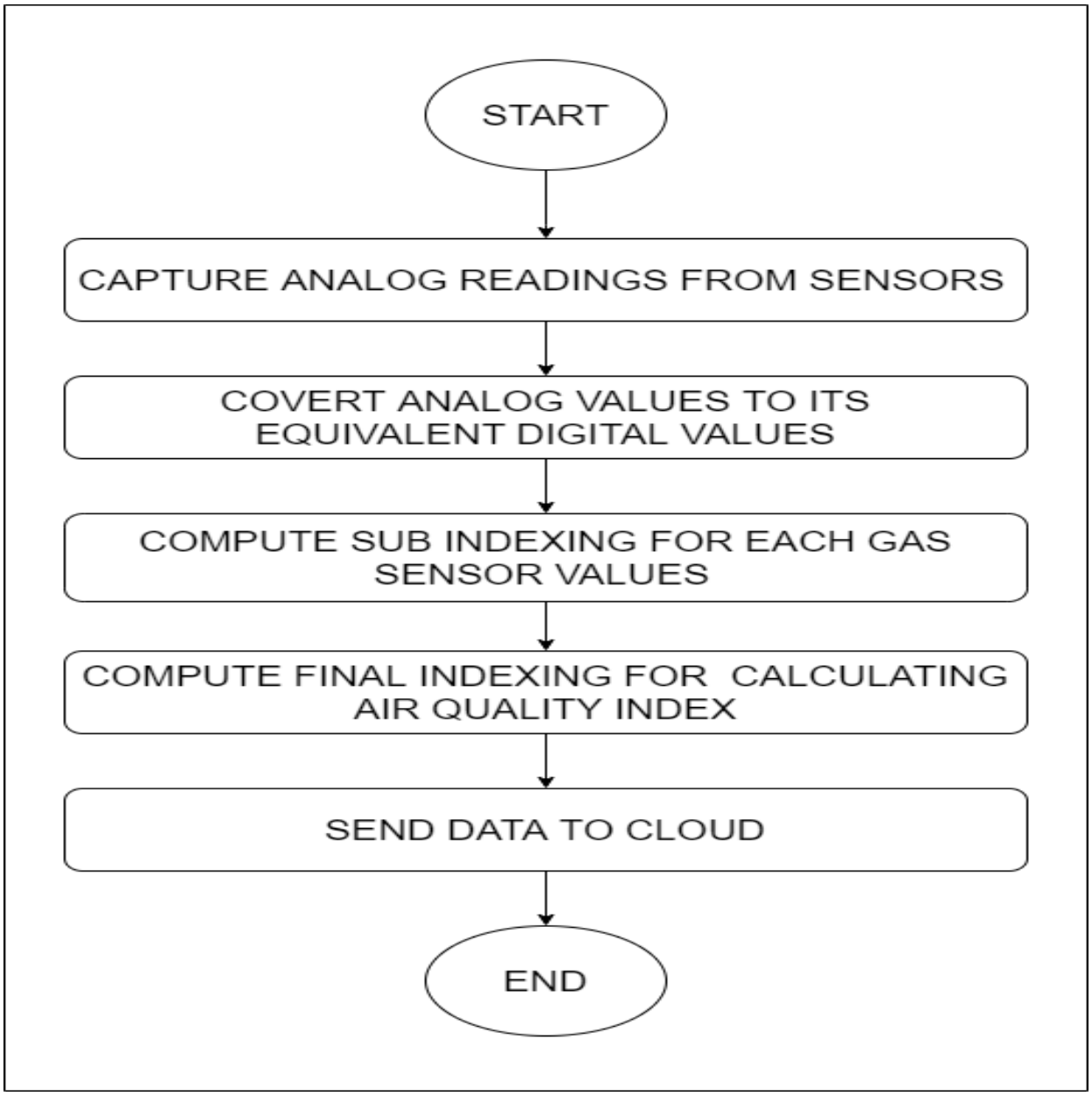


Figure 9.1: Station-side Workflow

9.2 Server-side Software

In the server software we used the PHP as back end language and HTML, CSS & JS used as front end language.

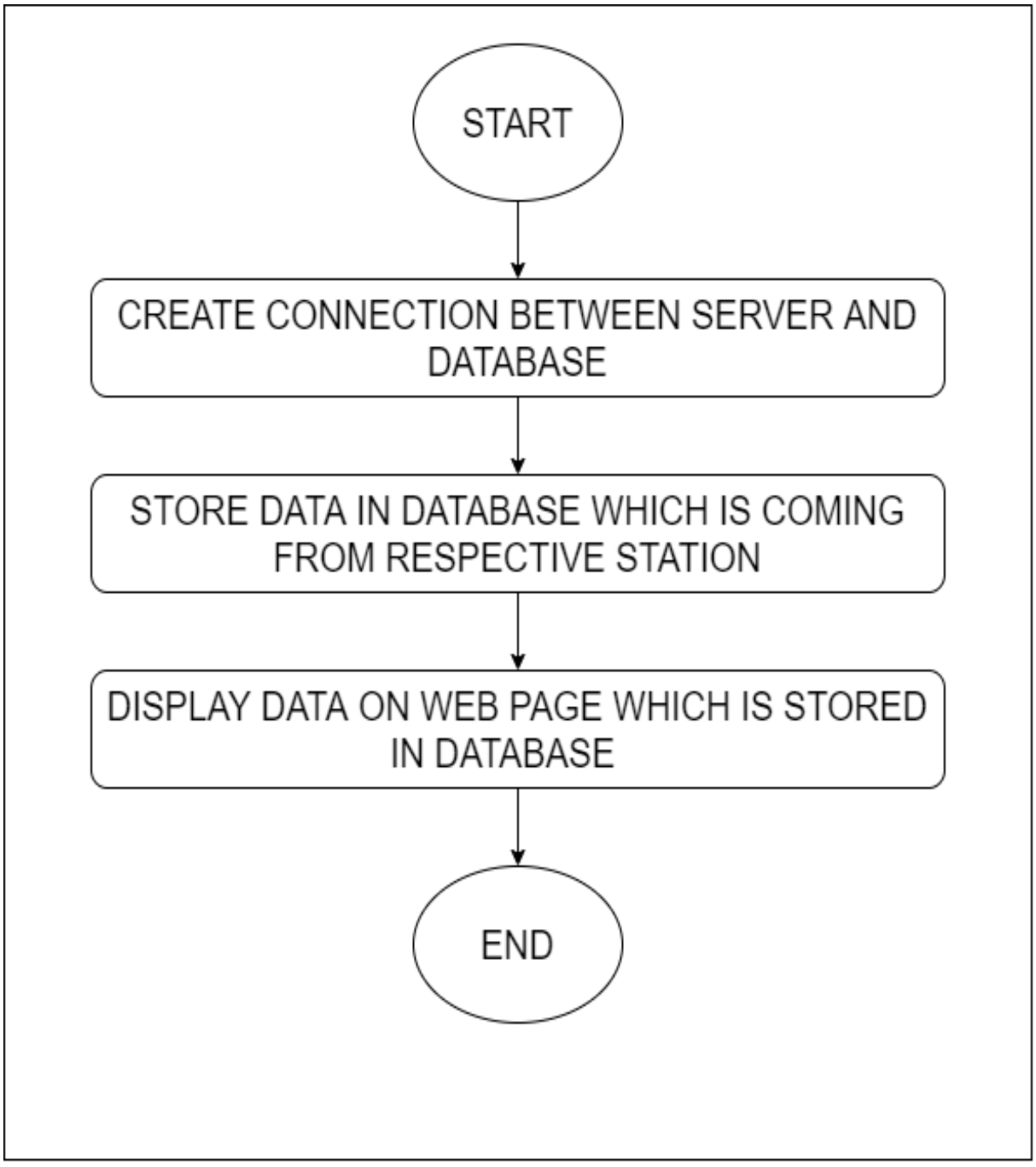
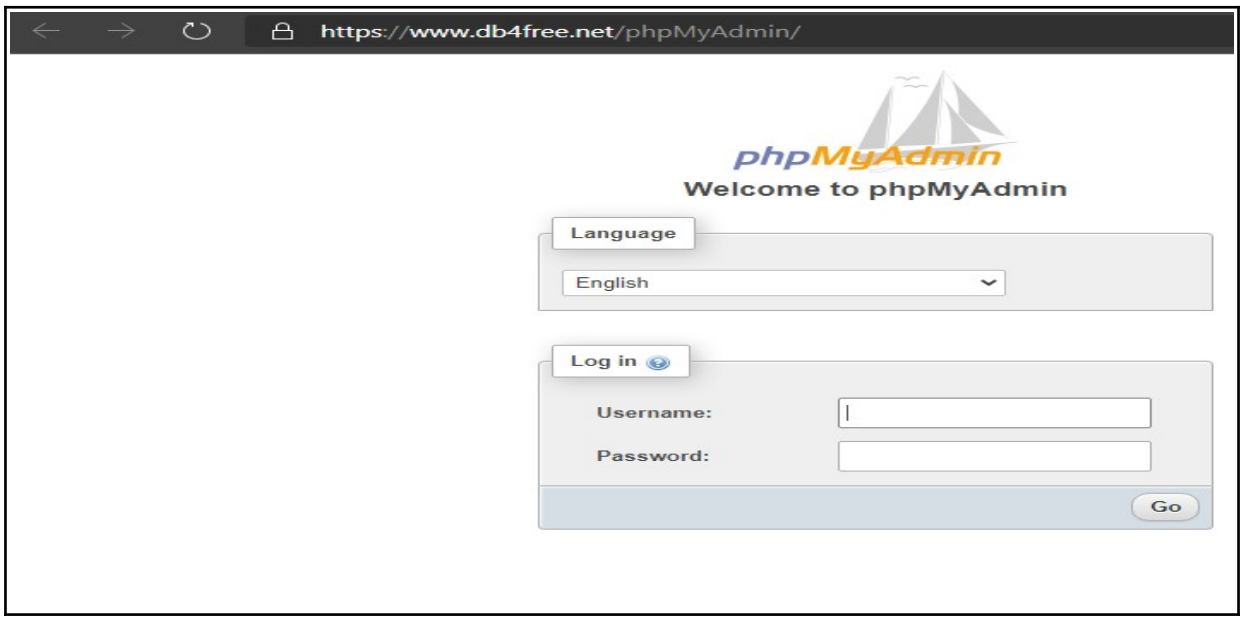


Figure 9.2: Server-side Workflow

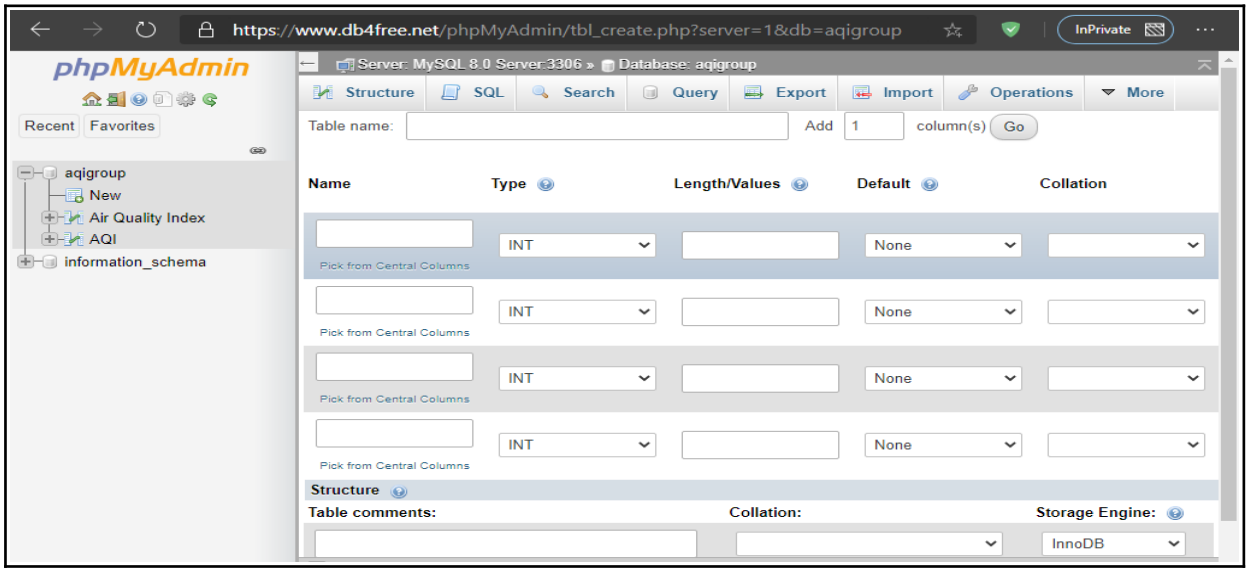
9.2.1 Steps Executed For Creating Database

1. Choose the type of database for storing data (for e.g.mysql,postgresql).We choose Mysql for database because php supports this database natively.
2. Choose right service provider for Mysql database. We choose the db4free database because this database service freely available for certain data Storage limit.
3. Create account for db4free and login.



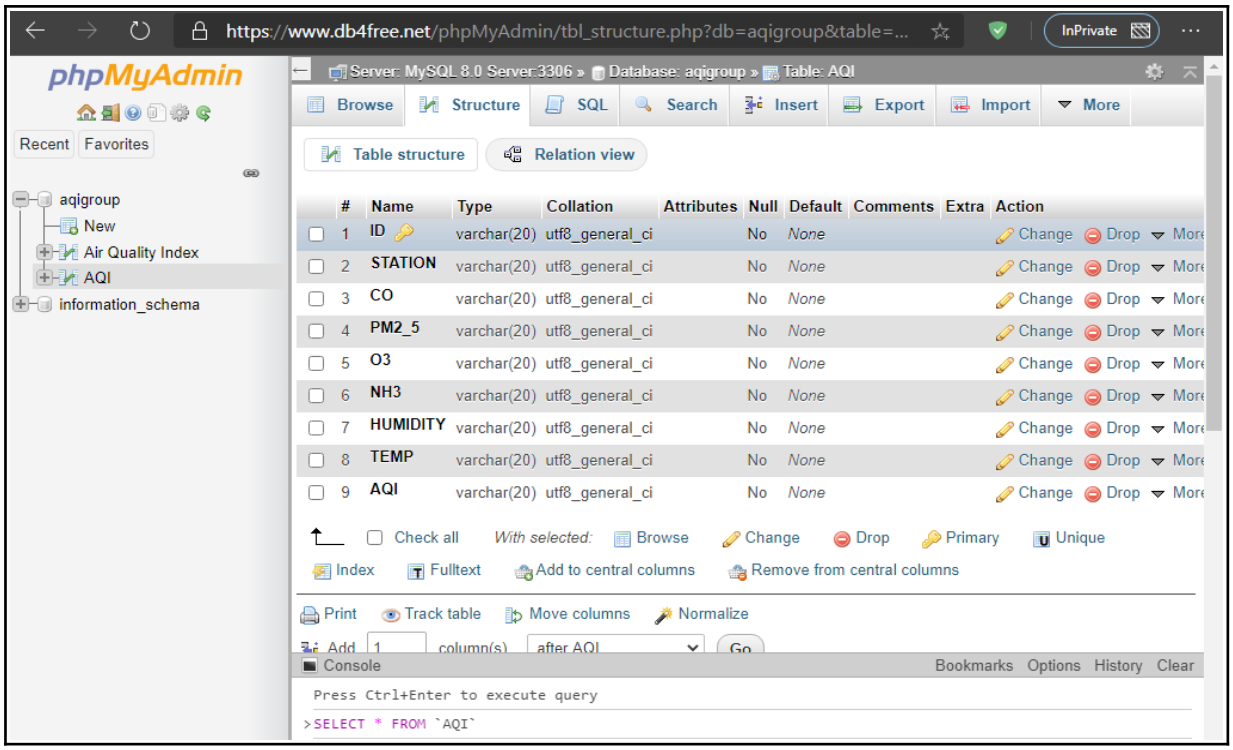
Screenshot 9.1: db4free Login Window

4. Create table for data storage according to database parameter.



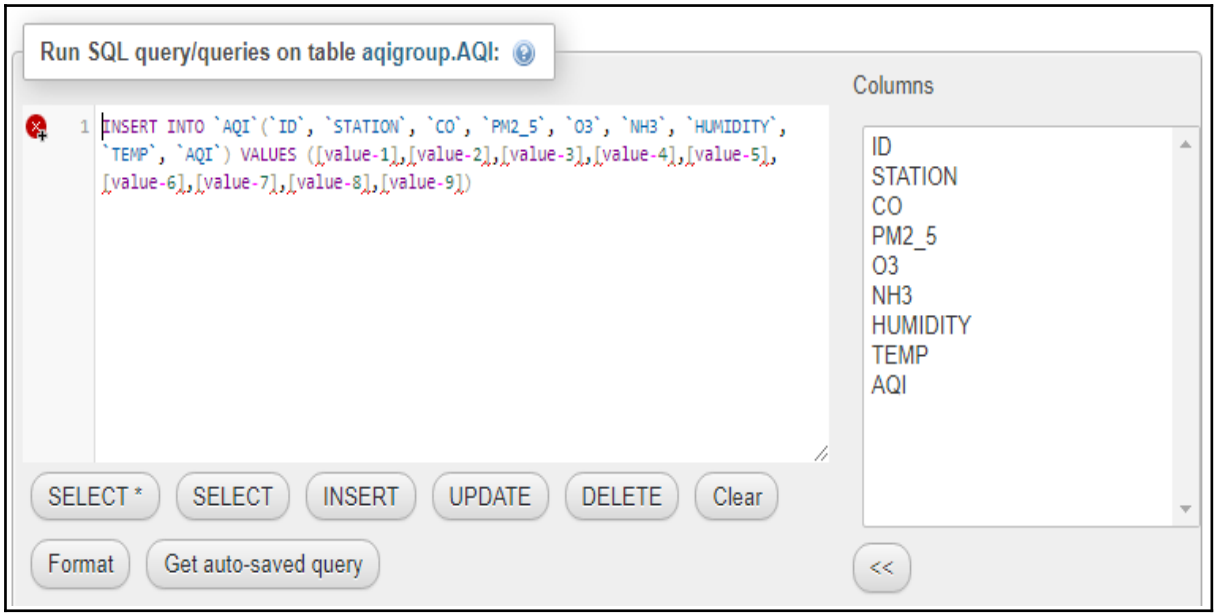
Screenshot 9.2: Database Parameter Settings

5. After the creating database check all the parameter characteristics.



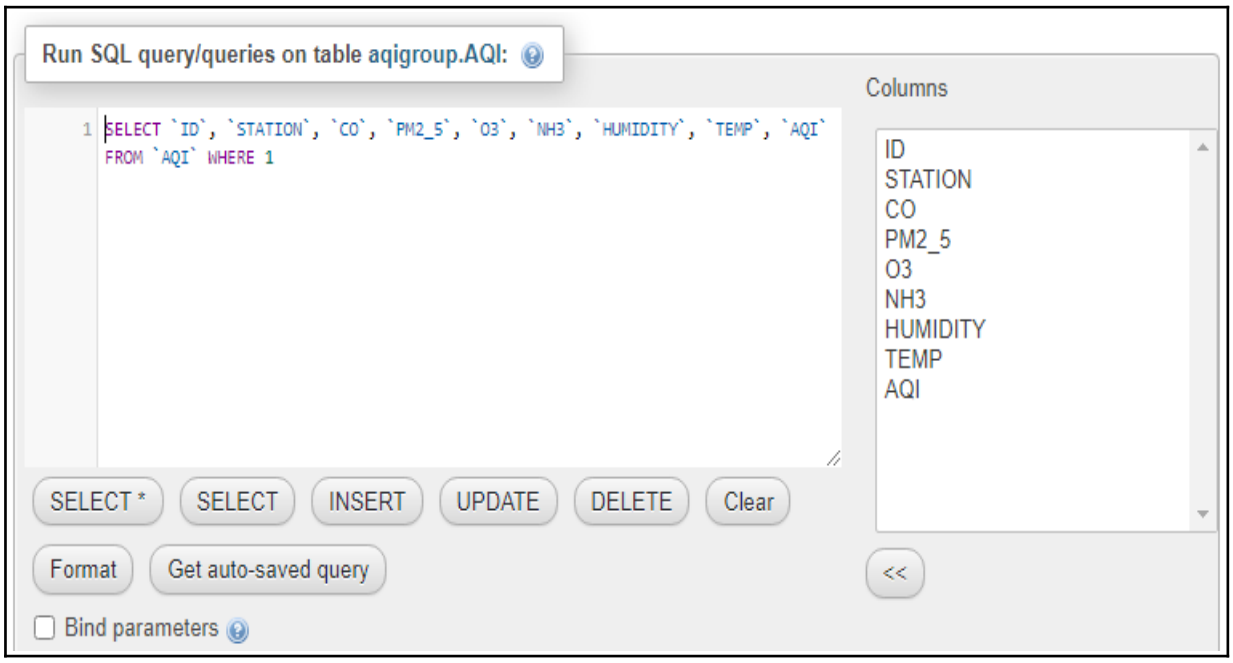
Screenshot 9.3: Structure After Creating Database

6. We need the queries for the inserting and selecting a data.
7. For inserting a data into table the query is present in INSERT option.



Screenshot 9.4: Insert Query

8. For display the data into table the query is present in SELECT option.



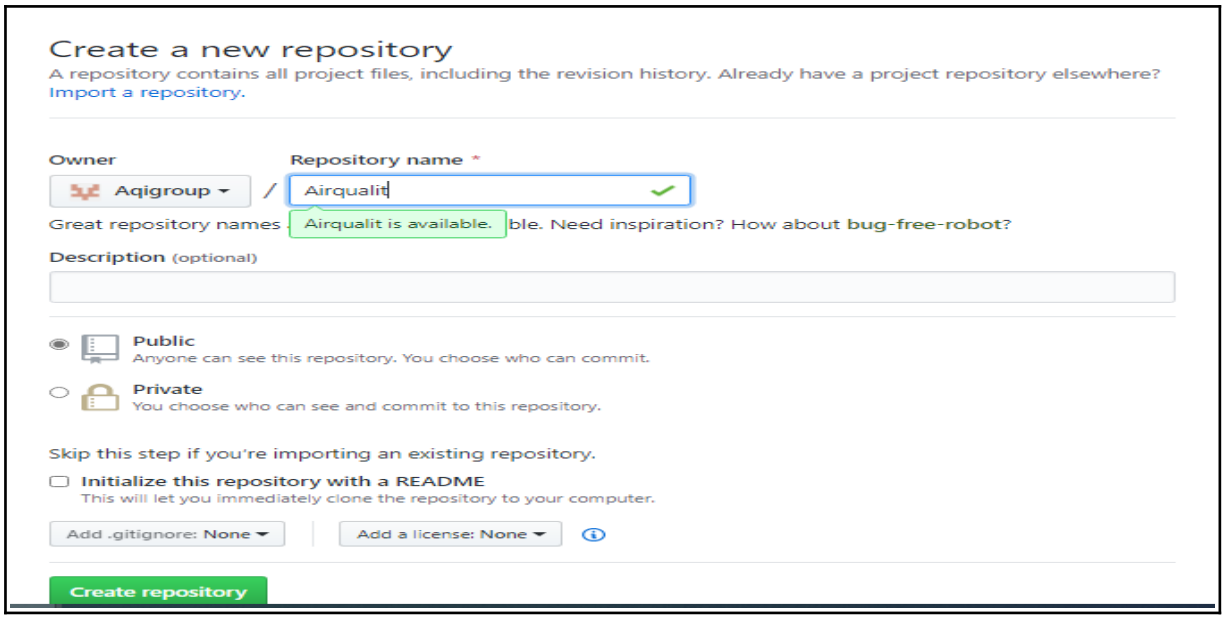
Screenshot 9.5: Select Query

9. All these queries required for php programming.

QR code 9:1: For More Information About db4free

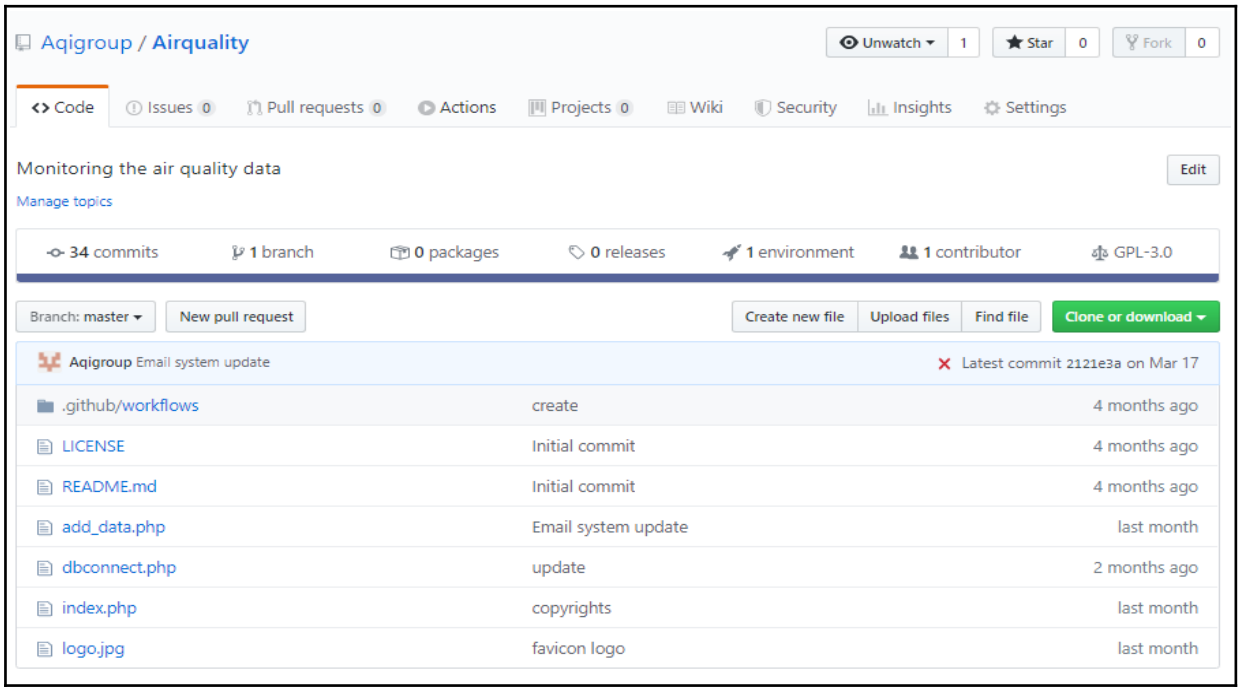
9.2.2 Steps Executed for create a repository on GitHub

1. Github is the version control system. We used this system for to control the bugs and errors in web application. It is also used to test code online. First we have created the account on Github.
2. Then we have create the new repository on github.



Screenshot 9.6: Creating New Repository

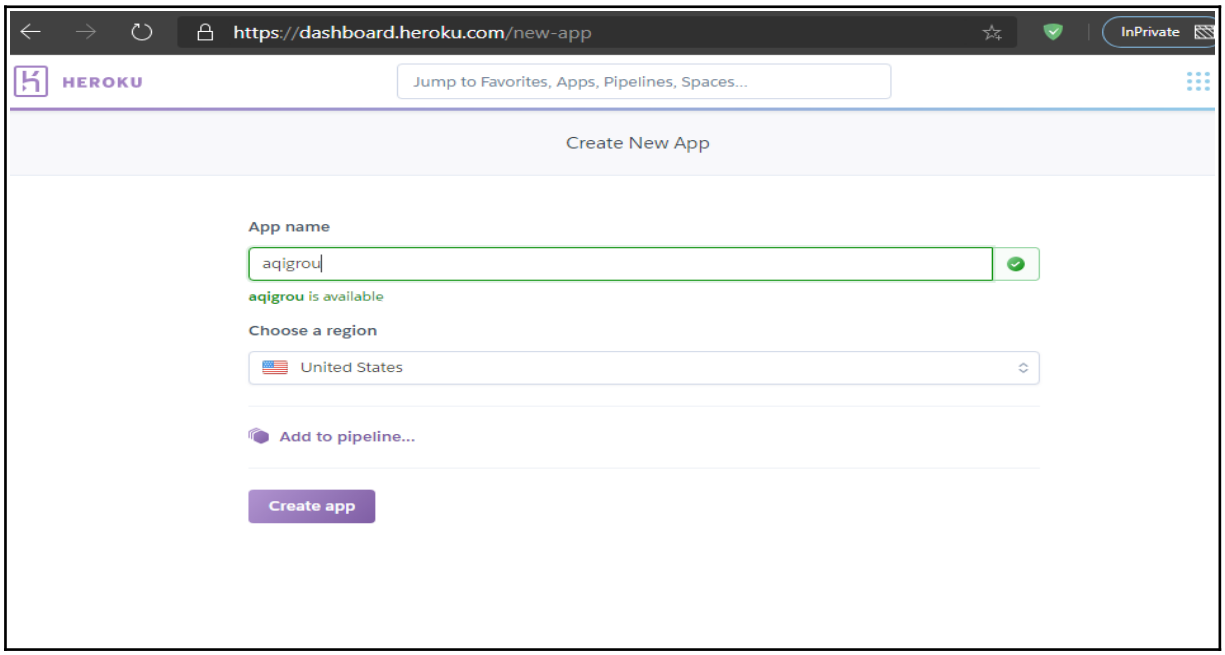
3. We upload the php code files on Github.



Screenshot 9.7: Uploading Files On GitHub

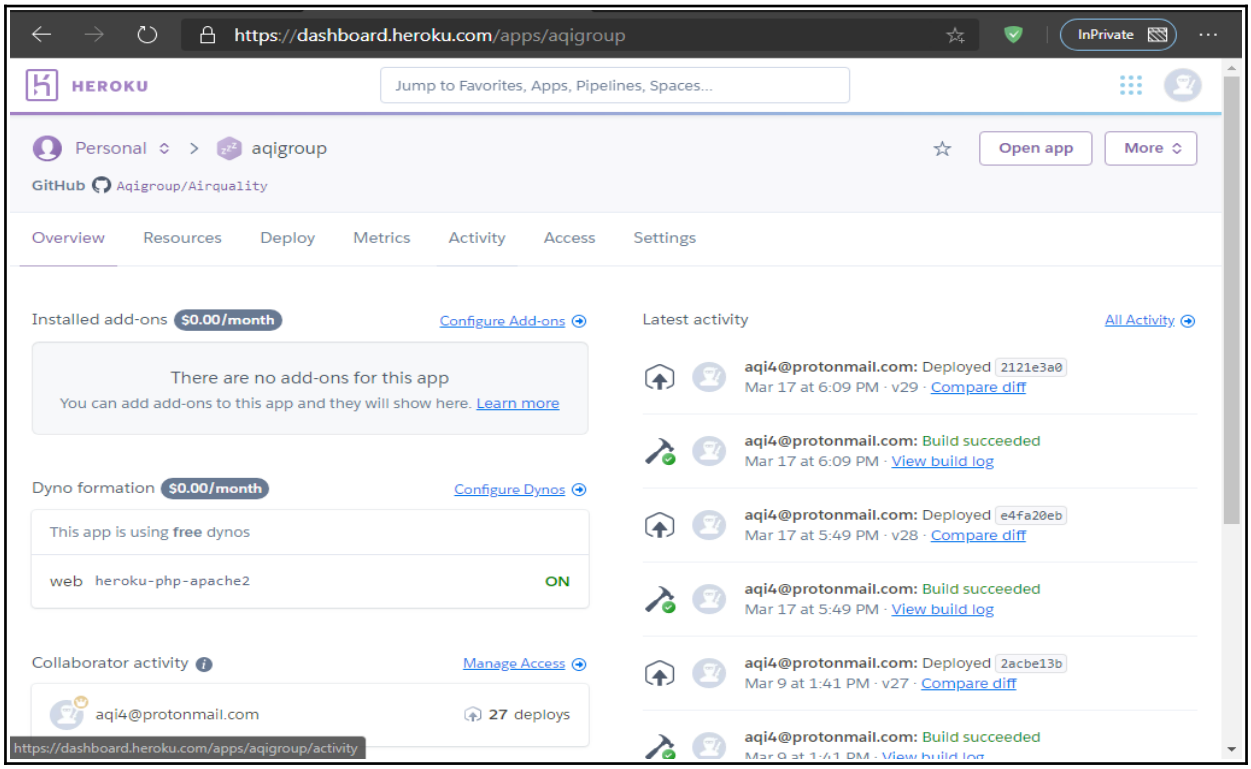
9.2.3 Steps Executed for create app on Heroku cloud

1. We have created an account and login into heroku cloud platform.
2. We have created new web application on heroku cloud platform.



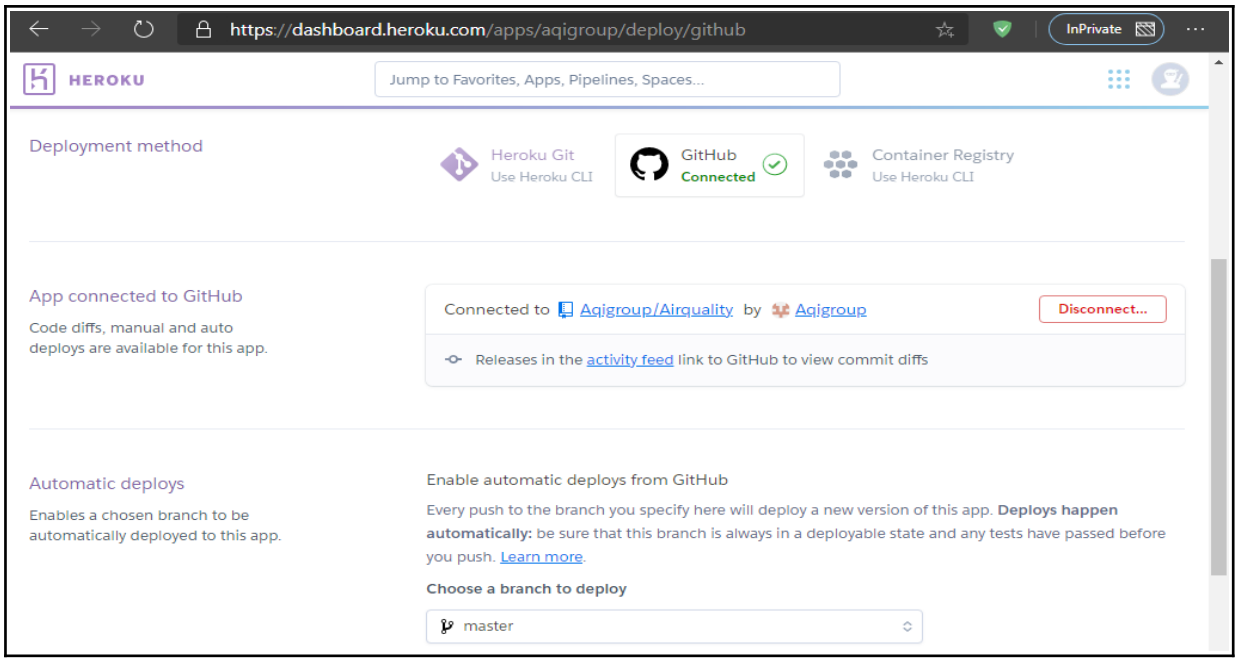
Screenshot 9.8: Creating New App On Heroku

3. After creating app we select the pricing option for this app.



Screenshot 9.9: Price Selection

4. We choose the deploy option for the app is Github and connect Github repository to the Heroku cloud application.



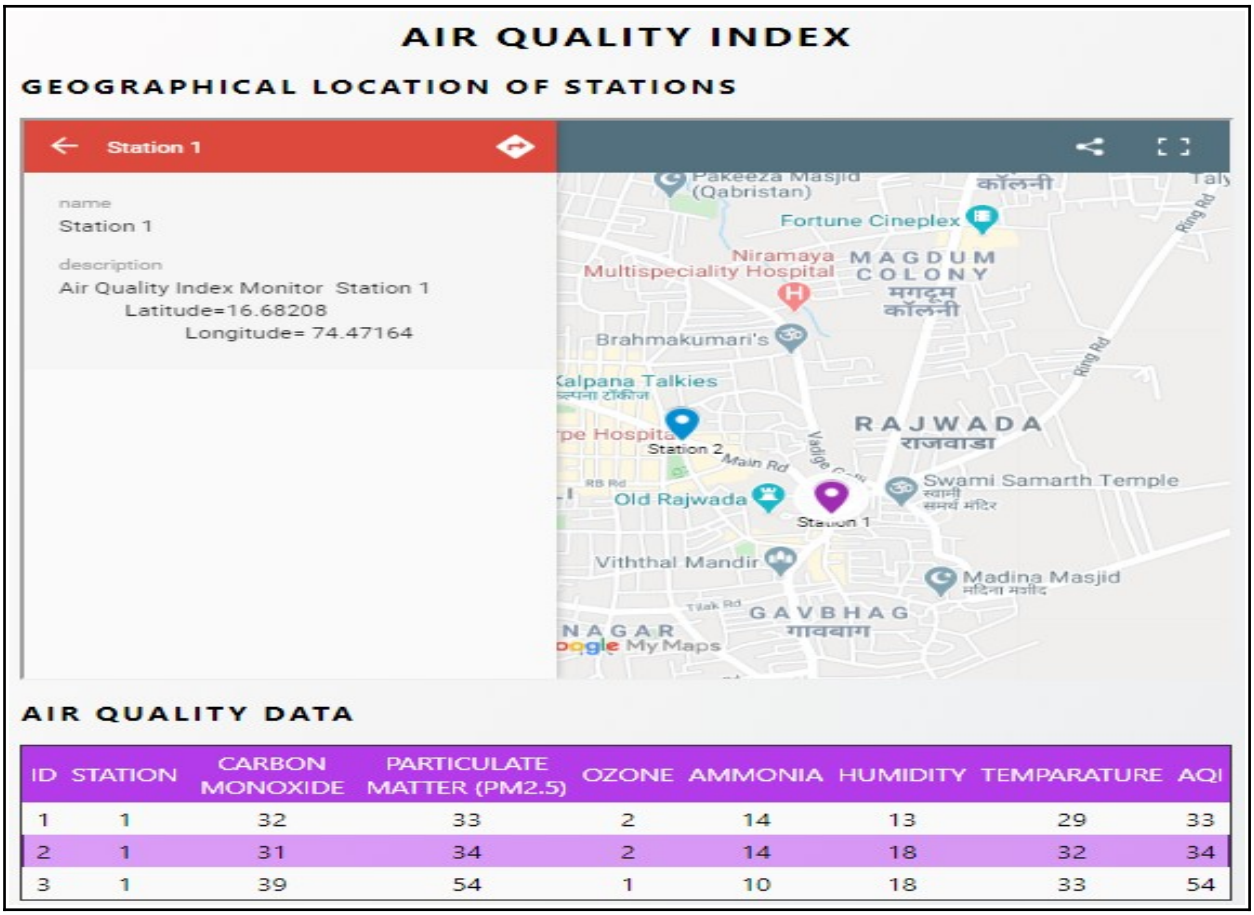
Screenshot 9.10: Deploying App On Heroku

5. According to commit changes the code on github is manually deployed using Heroku cloud platform.

QR code 9:3: For More Information About GitHub

QR code 9:2: For More Information About Heroku cloud

10. Results



ID	STATION	CARBON MONOXIDE	PARTICULATE MATTER (PM2.5)	OZONE	AMMONIA	HUMIDITY	TEMPARATURE	AQI
1	1	32	33	2	14	13	29	33
2	1	31	34	2	14	18	32	34
3	1	39	54	1	10	18	33	54

Screenshot 10.1: Webpage

QR code 10:1: Repository on GitHub

QR code 10:2: Webpage Link

11. Advantages & Disadvantages

11.1 Advantages

- Continuous update of change in data.
- Quality of air can be checked indoor as well as outdoor.
- Total real-time system.
- All sensors are used as accurate as all time.
- All sensors are have long life.
- In software continuous upgradation is possible due to use of GitHub.

11.2 Disadvantages

- Accuracy of sensors is little bit less.
- The method of measuring air quality is not long term solution.
- In project we used all software platforms are free so the data privacy is most important issue.

12. Conclusion & Future Scope

This project presents the technique of air quality monitoring. This technique is elaborately discussed in the project report. In the proposed system, one of the most preferred technique is cloud based air quality monitoring system. Using the same cloud data, website is hosted and data is displayed on the website.

As per upgradation we go for other techniques which is fulfil our air quality monitoring system. Present system designed to fulfil present condition but in future we update the system according to future conditions.

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