

Project submitted for the Degree of B. Tech in
Applied Electronics & Instrumentation
Engineering under West Bengal University of
Technology

AIR QUALITY SENSING AND MONITORING

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Arpan Chakraborty

Prajukti Das

Shovan Karmakar

CERTIFICATE OF APPROVAL

The project report titled “ **Air quality sensing and monitoring** ” prepared by , Arpan Chakraborty Roll No:11705514010 , Prajukti Das Roll No:11705514023 , Shovan Karmakar Roll No: 11705514028 ; is hereby approved and certified as a creditable study in technological subjects performed in a way sufficient for its acceptance for fulfilment of the degree for which it is submitted.

It is to be understood that by this approval, the undersigned do not, necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein, but approve the project only for the purpose for which it is submitted.

[Supervisor]

[Head of the Department]

Applied Electronics & Instrumentation Engineering

RECOMMENDATION

I hereby recommend that the project report titled “**Air quality sensing and monitoring**” prepared by Arpan Chakraborty, Roll No:11705514010, Prajukti Das, Roll No:11705514023, Shovan Karmakar, Roll No:11705514028 ; be accepted in fulfillment of the requirement for the Degree of Bachelor of Technology in Applied Electronics & Instrumentation Engineering, RCC Institute of Information Technology.

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(Supervisor)

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INTRODUCTION:

Continued exposure to environments with poor air quality is a major public health concern in developed and developing countries. It is estimated that the pollutants responsible for poor air quality cause nearly 2.5 million premature deaths per year world-wide. Significantly, around 1.5 million of these deaths are due to polluted indoor air, and it is suggested that poor indoor air quality may pose a significant health risk to more than half of the world's population. Due to its link with industrialisation, societal health problems associated with poor air quality disproportionately affects developed and developing nations – it is estimated that air pollution is responsible for the premature deaths. Remedial action to improve air quality is often easy to implement once airborne pollutants have been detected.

OVERVIEW OF PROJECT:

- This project provides a combination of process of sensing several gas levels in the air and also the ambient temperature and humidity, thus sensing the quality of the air.
- The levels of the gases and the temperature is displayed in a LCD display panel , which continuously shows the real time output values of the gas sensors , temperature and humidity sensor.

OBJECTIVE:

- To measure and display temperature and humidity level of the environment.
- To combine advanced detection technologies to produce an air quality sensing system with advanced capabilities to provide low cost comprehensive monitoring.
- To display the sensed data in user friendly format in LCD display panel.

REVIEW OF PAPERS:

A WiFi-enabled indoor air quality monitoring and control system:-

Published in: Control & Automation (ICCA), 2017 13th IEEE International Conference

Authors: Xiaoke Yang, Lingyu Yang, Jing Zhang

(School of Automation Science and Electrical Engineering, Beihang University, Beijing, 100191, China)

This paper proposes an open platform of a WiFi-enabled indoor air quality monitoring and control system, which could be incorporated into such a ‘smart building’ structure. The complete software and hardware design of this system is presented, along with a series of control experiments. The proposed system operates over an existing WiFi wireless network utilizing the MQTT protocol. It is capable of monitoring the indoor air quality as well as controlling an air purifier to regulate the particulate matters concentration. Experiment results under a real world office environment demonstrate the effectiveness of the proposed design.

A low-power real-time air quality monitoring system using LPWAN based on LoRa:-

Published in: Solid-State and Integrated Circuit Technology (ICSICT), 2016 13th IEEE International Conference

Authors: Sujuan Liu, Chuyu Xia, Zhenzhen Zhao

(College of Electronic Information and Control Engineering, Beijing University of Technology, 100124, China)

This paper presents a low-power real-time air quality monitoring system based on the LoRa Wireless Communication technology. The proposed system can be laid out in a large number in the monitoring area to form sensor network. The system integrates a single-chip microcontroller, several air pollution sensors (NO₂, SO₂, O₃, CO, PM₁, PM₁₀, PM_{2.5}), LongRange (LoRa) - Modem, a solar PV-battery part and graphical user interface (GUI). As communication module LoRa sends the data to the central monitoring unit and then the data would be saved in the cloud. The range tests at an outdoor area show that LoRa is able to reach to approximately 2Km. The TX power is only about 110mA which is lower compared with other used wireless technology. An easy to use GUI was designed in the system. Based on LoRa technology, GUI, and Solar PV-

battery part the system has several progressive features such as low cost, long distance, high coverage, long device battery life, easy to operate.

IoT enabled proactive indoor air quality monitoring system for sustainable health management:-

Published in: Computing and Communications Technologies (ICCCT), 2017 2nd International Conference

Authors: M.F.M Firdhous, B.H Sudantha, P.M Karunaratne (Dept. of Information Technology, University of Moratuwa, Sri Lanka)

This paper proposes an IoT based indoor air quality monitoring system for tracking the ozone concentrations near a photocopier machine. The experimental system with a semiconductor sensor capable of monitoring ozone concentrations was installed near a high volume photocopier. The IoT device has been programmed to collect and transmit data at an interval of five minutes over blue tooth connection to a gateway node that in turn communicates with the processing node via the WiFi local area network. The sensor was calibrated using the standard calibration methods. As an additional capability, the proposed air pollution monitoring system can generate warnings when the pollution level exceeds beyond a predetermined threshold value.

A wireless system for indoor air quality monitoring:-

Published in: Industrial Electronics Society , IECON 2016 - 42nd Annual Conference of the IEEE

Authors: R du Plessis, A Kumar, GP Hancke

(Department of Electrical, Electronic and Computer Engineering, University of Pretoria, South Africa)

This paper describes the development of a wireless monitoring system which can be deployed in a building. The system measures carbon dioxide, carbon monoxide and temperature. The system developed in this paper can serve as the monitoring component of a HVAC control system and function as an indoor air quality monitor independently.

Polluino: An efficient cloud-based management of IoT devices for air quality monitoring:-

Published in: Research and Technologies for Society and Industry Leveraging a better tomorrow (RTSI), 2016 IEEE 2nd International Forum

The Internet of Things paradigm originates from the proliferation of intelligent devices that can sense, compute and communicate data streams in a ubiquitous information and communication network. The great amounts of data coming from these devices introduce some challenges related to the storage and processing capabilities of the information. This strengthens the novel paradigm known as Big Data. In such a complex scenario, the Cloud computing is an efficient solution for the managing of sensor data. This paper presents Polluino, a system for monitoring the air pollution via Arduino. Moreover, a Cloud-based platform that manages data coming from air quality sensors is developed.

An embedded system model for air quality monitoring:-

Published in: Computing for Sustainable Global Development (INDIACom), 2016 3rd International Conference

Authors: Sneha Jangid, Sandeep Sharma (School of ICT, Gautam Buddha University, Greater Noida, India)

Objective of the paper is to present a system model which can facilitate the assessment of health impacts caused due to indoor air pollutant as well as outdoor and can intimate the human prior about the risk he/she going to have, here we are focusing our work in context to allergic patients as they will be informed by this tool such that they can secure themselves without actually experiencing the risk factors, here a sensing network based microcontroller equipped with gas sensors, optical dust particle sensor, humidity and temperature sensor has been used for air quality monitoring. The design included various units mainly: sensing unit, processing unit, power unit, display unit, communication unit. This work will apply the techniques of electrical engineering with the knowledge of environmental engineering by using sensor networks to measure Air Quality Parameters.

A real-time ambient air quality monitoring wireless sensor network for schools in smart cities:-

Published in: Smart Cities Conference (ISC2), 2015 IEEE First International

Authors:H. Ali, J. K. Soe, Steven. R. Wel

(School of Electrical Engineering & Computer Science, The University of Newcastle, Callaghan, NSW 2308, Australia)

In this paper, a low-cost solar-powered air quality monitoring system based on ZigBee wireless network system technology is presented. The solar powered network sensor nodes can be deployed by schools to collect and report real-time data on carbon monoxide (CO), nitrogen dioxide (NO₂), dust particles, temperature, and relative humidity. The proposed system allows schools to monitor air quality conditions on a desktop/laptop computer through an application designed using LabVIEW and provides an alert if the air quality characteristics exceed acceptable levels. They tested the sensor network successfully at the Singapore campus of the University of Newcastle, Australia. The experimental results obtained by them demonstrated that the sensor network can provide high-quality air quality measurements over a wide range of CO, NO₂ and dust concentrations.

A smart sensor system for air quality monitoring and massive data collection:-

Published in: Information and Communication Technology Convergence (ICTC), 2015 International Conference

Authors: Yonggao Yang, Lin Li

(Department of Computer Science, Prairie View A&M University, Prairie View, TX 77446, U.S.A)

Air pollution has been a global challenge for environment protection. Effectively collecting and scientifically visualizing the air quality data can better help us monitor the environment and address related issues. This article presents a smart sensor system for air quality monitoring which consists of three units: the smart sensor unit, the smartphone, and a server. The smart

BLOCK DIAGRAM:

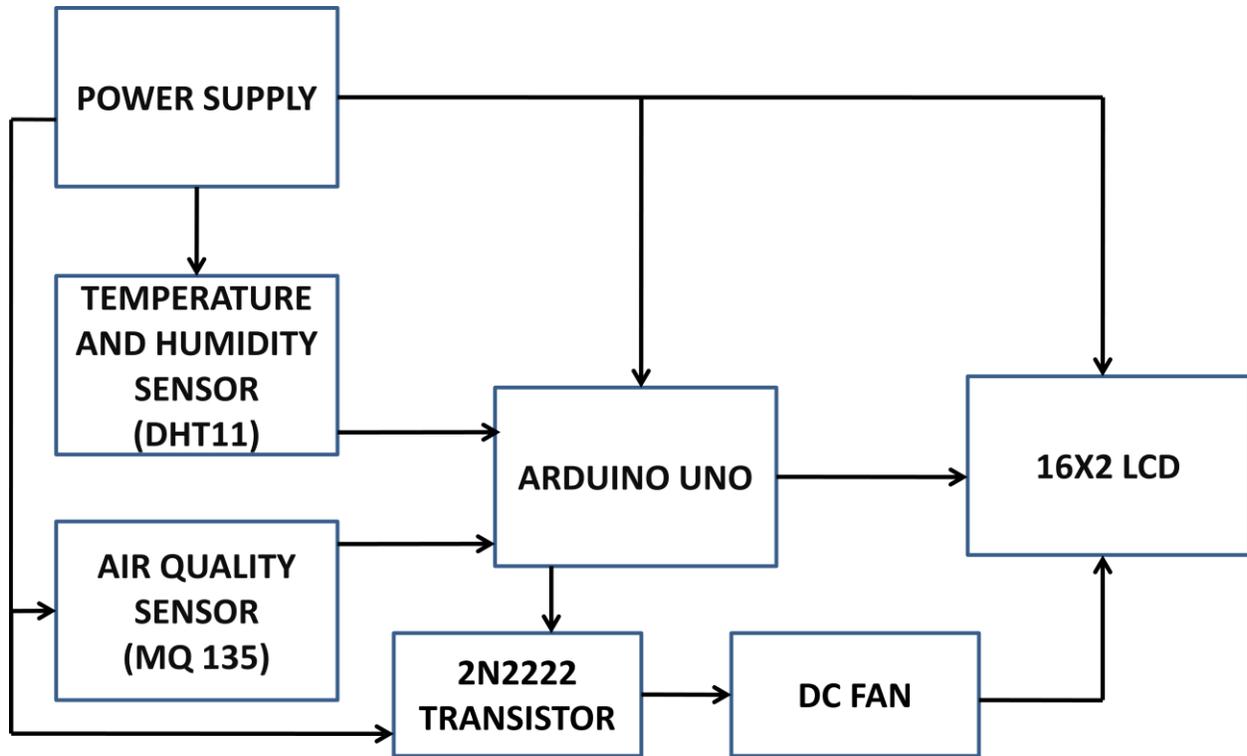


Fig 1(a): Block Diagram of Air Quality Monitoring and Sensing

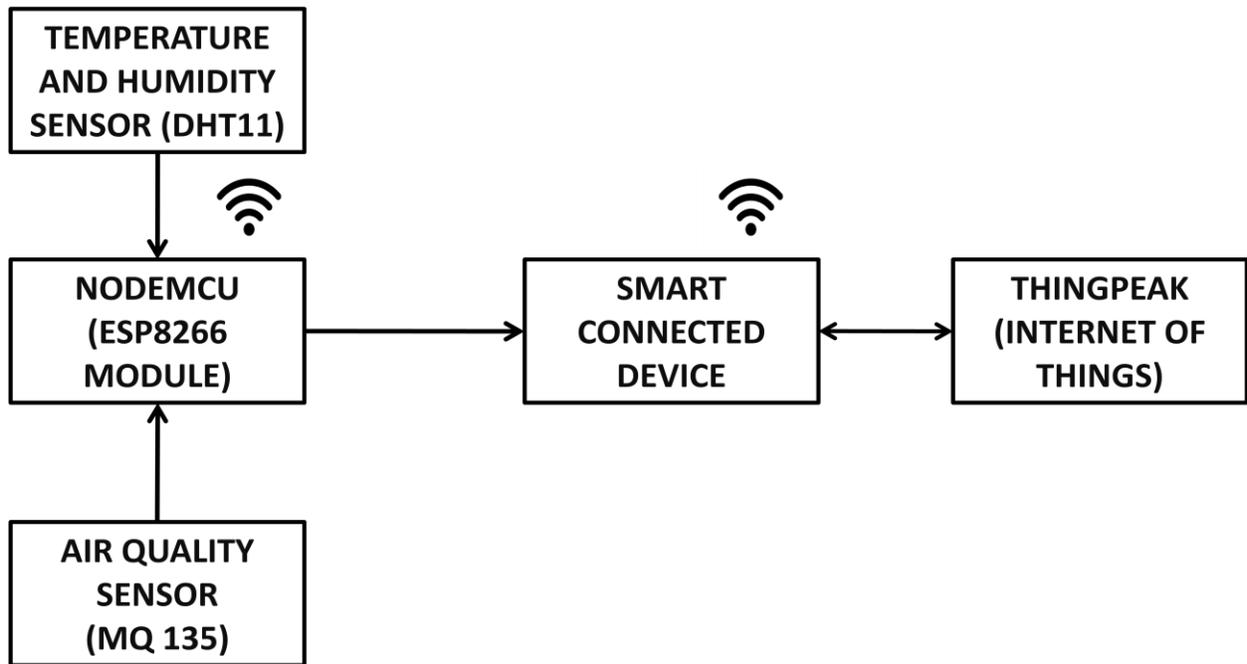


Fig 1(b): Block Diagram of sending the data to THINGSPEAK using NodeMCU

HARDWARE REQUIREMENTS:

➤ For Different Parameter Sensing:-

- Temperature and Humidity sensor (DHT11)
- Air Quality sensor (MQ 135)
- 2n2222 Transistor
- DC Fan
- Potentiometer
- 16x2 LCD Panel
- NodeMCU
- Arduino Uno

➤ For Power Supply:-

- Step down transformer (12-0-12 V,1 A)
- Diodes
- Voltage Regulator (7805)
- Capacitors (0.01 micro Farad, 470 micro Farad)
- Wires

SOFTWARE REQUIREMENTS:

- Arduino (Version 1.8.2)
- THINGSPEAK website

COMPONENT DESCRIPTION:

Temperature and humidity sensor (DHT11):-

Product Description:

DHT11 digital temperature and humidity sensor is a composite Sensor contains a calibrated digital signal output of the temperature and humidity. Application of a dedicated digital modules collection technology and the temperature and humidity sensing technology, to ensure that the product has high reliability and excellent long-term stability. The sensor includes a resistive sense of wet components and an NTC temperature measurement devices, and connected with a high-performance 8-bit microcontroller.

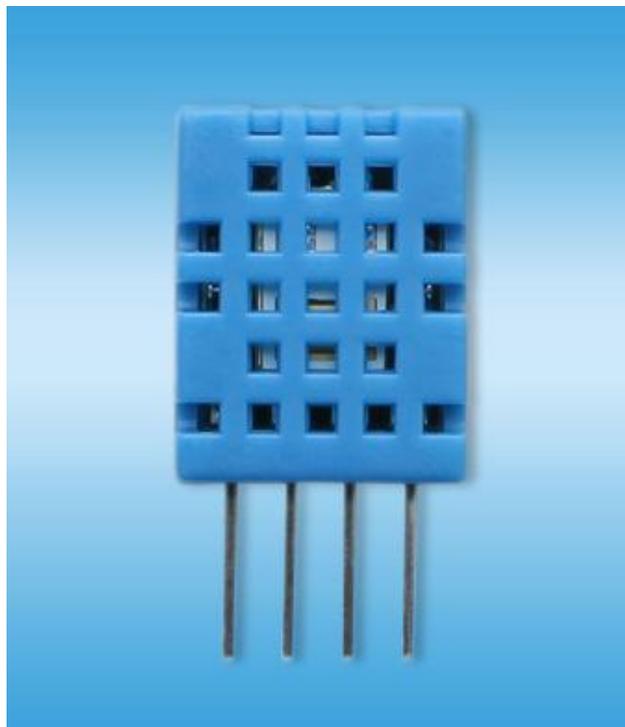


Fig 2: DHT11 Sensor

Pin Description:

- 1, the VDD power supply 3.5~5.5V DC
- 2 DATA serial data, a single bus
- 3, NC, empty pin
- 4, GND, used to connect the module to system ground

Air Quality Sensor (MQ135):-

Product Description:

Air quality click is suitable for detecting ammonia (NH₃), nitrogen oxides (NO_x) benzene, smoke, CO₂ and other harmful or poisonous gases that impact air quality. The MQ-135 sensor unit has a sensor layer made of tin dioxide (SnO₂), an inorganic compound which has lower conductivity in clean air than when polluting gases are present. To calibrate Air quality, use the on-board potentiometer to adjust the load resistance on the sensor circuit.



Fig. 3: MQ135 Sensor

Pin Description:

- 1, the VDD power supply 5V DC
- 2,GND , used to connect the module to system ground
- 3, DIGITAL OUT, You can also use this sensor to get digital output from this pin, by setting a threshold value using the potentiometer
- 4, ANALOG OUT, This pin outputs 0-5V analog voltage based on the intensity of the gas.

2N2222 Transistor:-

Product Description:

The 2N2222 is a common NPN bipolar junction transistor (BJT) used for general purpose low-power amplifying or switching applications. It is designed for low to medium current, low power, medium voltage, and can operate at moderately high speeds. It was originally made in the TO-18 metal can as shown in the picture. The 2N2222 is considered a very common transistor and is used as an exemplar of an NPN transistor. It is frequently used as a small-signal transistor and it remains a small general purpose transistor of enduring popularity.

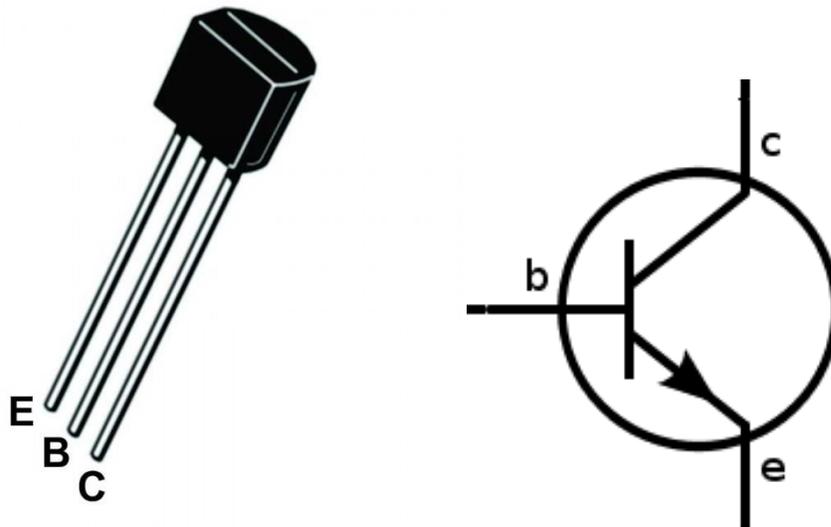


Fig. 4: 2N2222 Transistor

DC Fan:-

Product Description:

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor.



Fig 5: DC Motor with Fan

Potentiometer:-

Product Description:

A potentiometer is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat. The measuring instrument called a potentiometer is essentially a voltage divider used for measuring electric potential (voltage); the component is an implementation of the same principle, hence its name.



Fig 6: Potentiometer

16X2 LCD Panel:-**Product Description:**

A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome.^[1] LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden, such as preset words, digits, and seven-segment displays.

Pin Description:

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	V _{CC}
3	Contrast adjustment; through a variable resistor	V _{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V _{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

Table 1: Pin Description of 16x2 LCD Panel

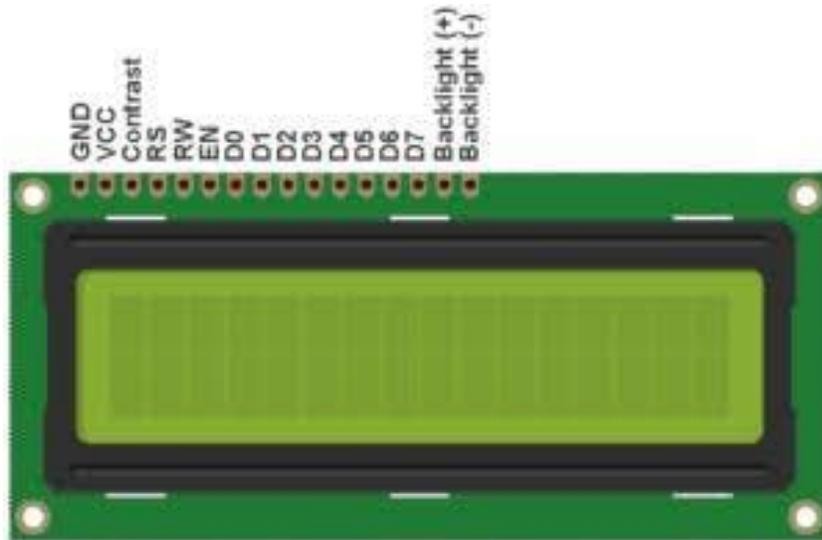


Fig 7: 16x2 LCD Display

Arduino Uno:-

Product Description:

Arduino is an open source computer hardware and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world.

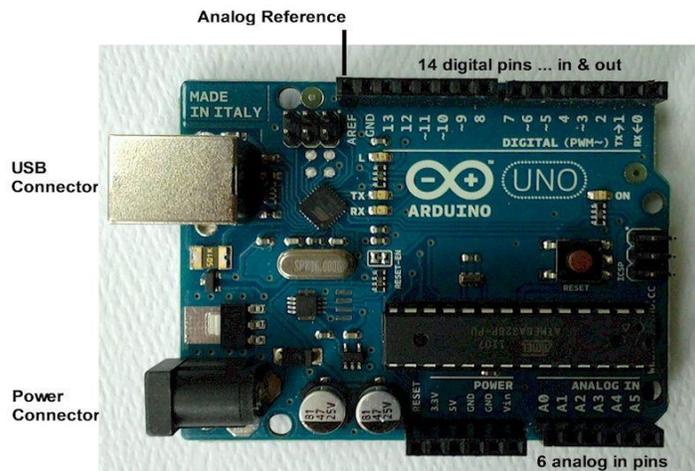


Fig 8: Arduino Uno

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (*shields*) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler tool chains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

Pin Description:

Pin Category	Pin Name	Details
Power	Vin, 3.3V, 5V, GND	<p>Vin: Input voltage to Arduino when using an external power source.</p> <p>5V: Regulated power supply used to power microcontroller and other components on the board.</p> <p>3.3V: 3.3V supply generated by on-board voltage regulator. Maximum current draw is 50mA.</p> <p>GND: ground pins.</p>
Reset	Reset	Resets the microcontroller.
Analog Pins	A0 – A5	Used to provide analog input in the range of 0-5V
Input/Output Pins	Digital Pins 0 - 13	Can be used as input or output pins.
Serial	0(Rx), 1(Tx)	Used to receive and transmit TTL serial data.
External Interrupts	2, 3	To trigger an interrupt.
PWM	3, 5, 6, 9, 11	Provides 8-bit PWM output.
SPI	10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK)	Used for SPI communication.
Inbuilt LED	13	To turn on the inbuilt LED.
TWI	A4 (SDA), A5 (SCA)	Used for TWI communication.
AREF	AREF	To provide reference voltage for input voltage.

Table 2: Pin Description of Arduino Uno

Technical Specification:

Microcontroller	ATmega328P – 8 bit AVR family microcontroller
Operating Voltage	5V
Recommended Input Voltage	7-12V
Input Voltage Limits	6-20V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
Flash Memory	32 KB (0.5 KB is used for Bootloader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz

Table 3: Technical Specification of Arduino Uno

NodeMCU:-**Product Description:**

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266.

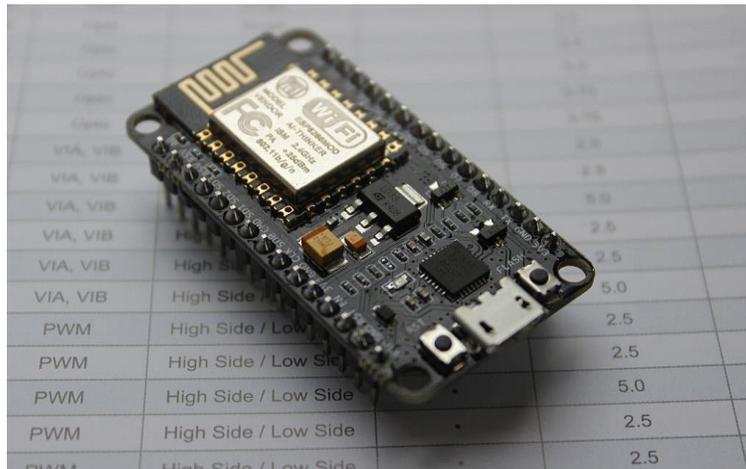


Fig 9: NodeMCU

COST ESTIMATION STRUCTURE:

Sl. No.	Name of Components	Cost (Rs.)
1.	Arduino Uno	400
2.	DTH11	150
3.	Bread board	60
4.	Jumper Wires	3/piece
5.	12-0-12 Transformer	130
6.	7805	20
7.	Capacitor	5/piece
8.	Resistances	3/piece
9.	16x2 LCD	140
10.	MQ 135	150
11.	NodeMCU	400
12.	DC Fan	20
13.	Potentiometer	10/piece
14.	2N222 Transistor	5/piece

Table 4: Cost of different Components

WORK PLAN:

Sl No.	Duration	Work done/will be done
1.	August'17-September'17	Selection of Project topic and study of the project topic.
2.	October '17	Study of previous work done related to our topic and preparing a literature review.
3.	November'17	Purchase of required components and making of a 5V power supply, and sensing of temperature and humidity using DTH11 sensor.
4.	December'17-May'18	Sensing of air quality using MQ135 and displaying the values on an LCD panel and sending the data to ThingSpeak Platform using NodeMCU. And controlling the speed of Fan based on temperature sensed by DHT11.

Table 5: Work Plan

WORK DONE:

Connections:

- DTH11's voltage, ground is connected to +5V and 0V and signal can be connected to any Digital Pin 8 of Arduino Uno.

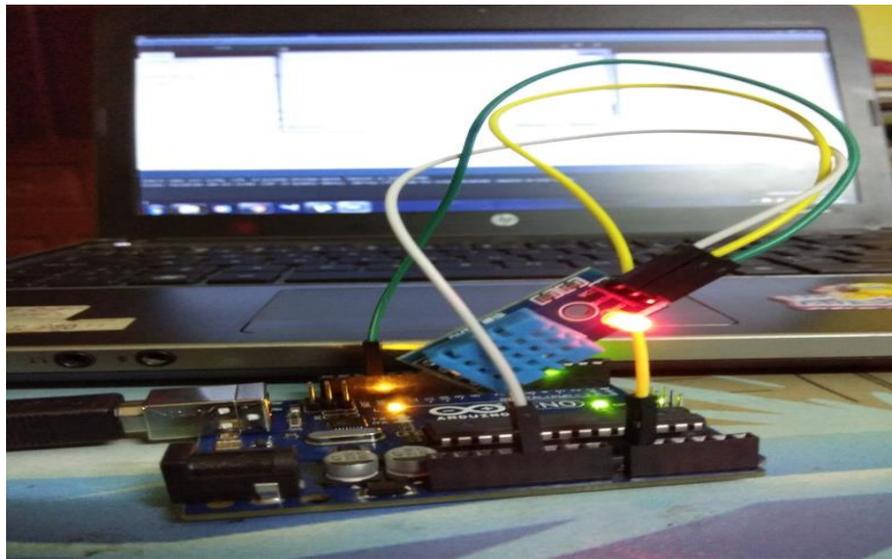


Fig 10: Connection of DTH11 with Arduino Uno

- MQ135's voltage and ground are connected to +5V and 0V and analog output pin is connected to analog Pin A0 of Arduino Uno.
- LCD RS pin to digital pin 12, Enable pin to digital pin 11, D4 pin to digital pin 5, D5 pin to digital pin 4, D6 pin to digital pin 3, D7 pin to digital pin 2, R/W pin to ground, VSS pin to ground, VCC pin to 5V, 10K resistor ends to +5V and ground and wiper to LCD VO pin.

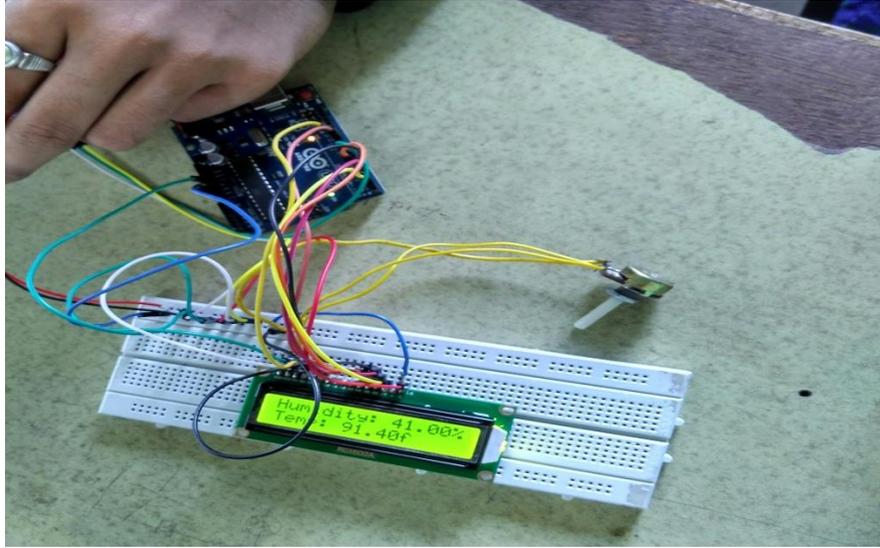


Fig 11: Connection of LCD with Arduino

- The data pins of DHT11 are connected to Digital pin of NodeMCU and that of MQ135 is connected to Analog Pin.

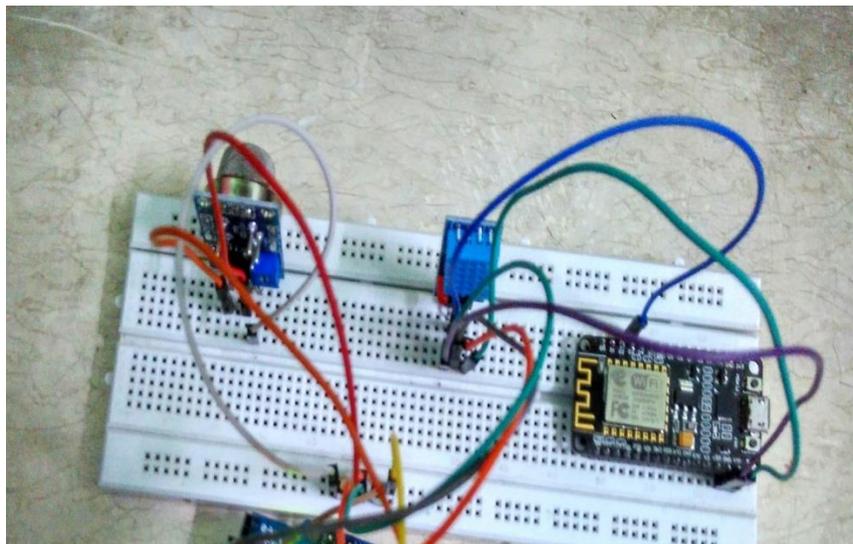


Fig 12: Connection of DHT11 and MQ135 with NodeMCU

- The base of 2N2222 transistor is connected to a pwm pin of Arduino Uno and the emitter and collector of transistor is connected to the DC Fan and supplied with 9V battery (in Forward Bias). The other connections are kept the same.

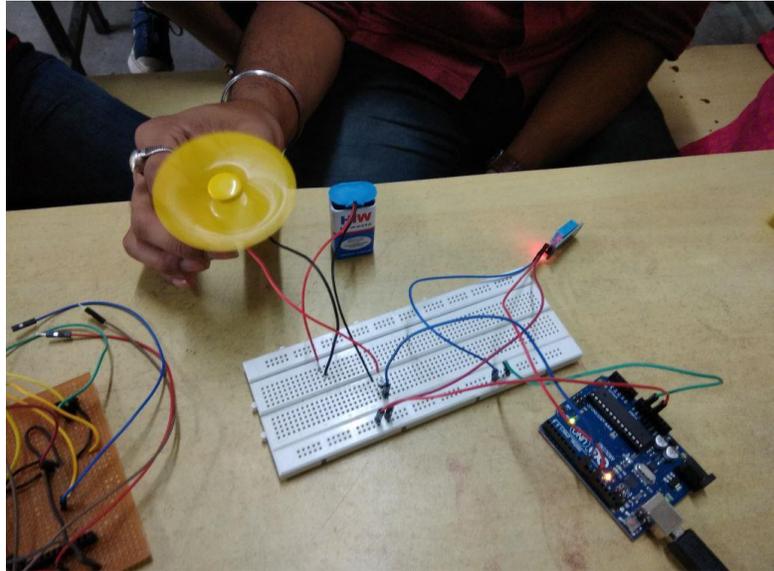
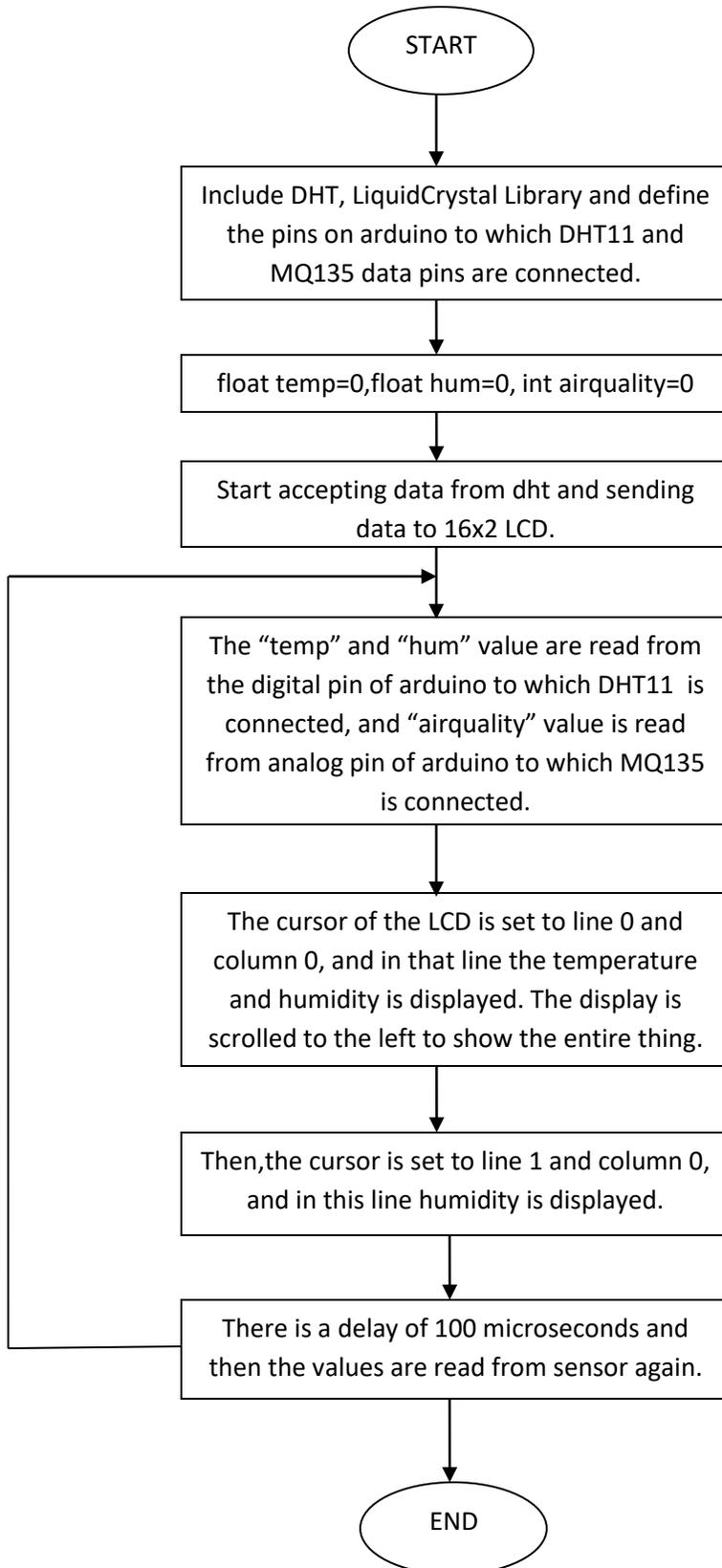
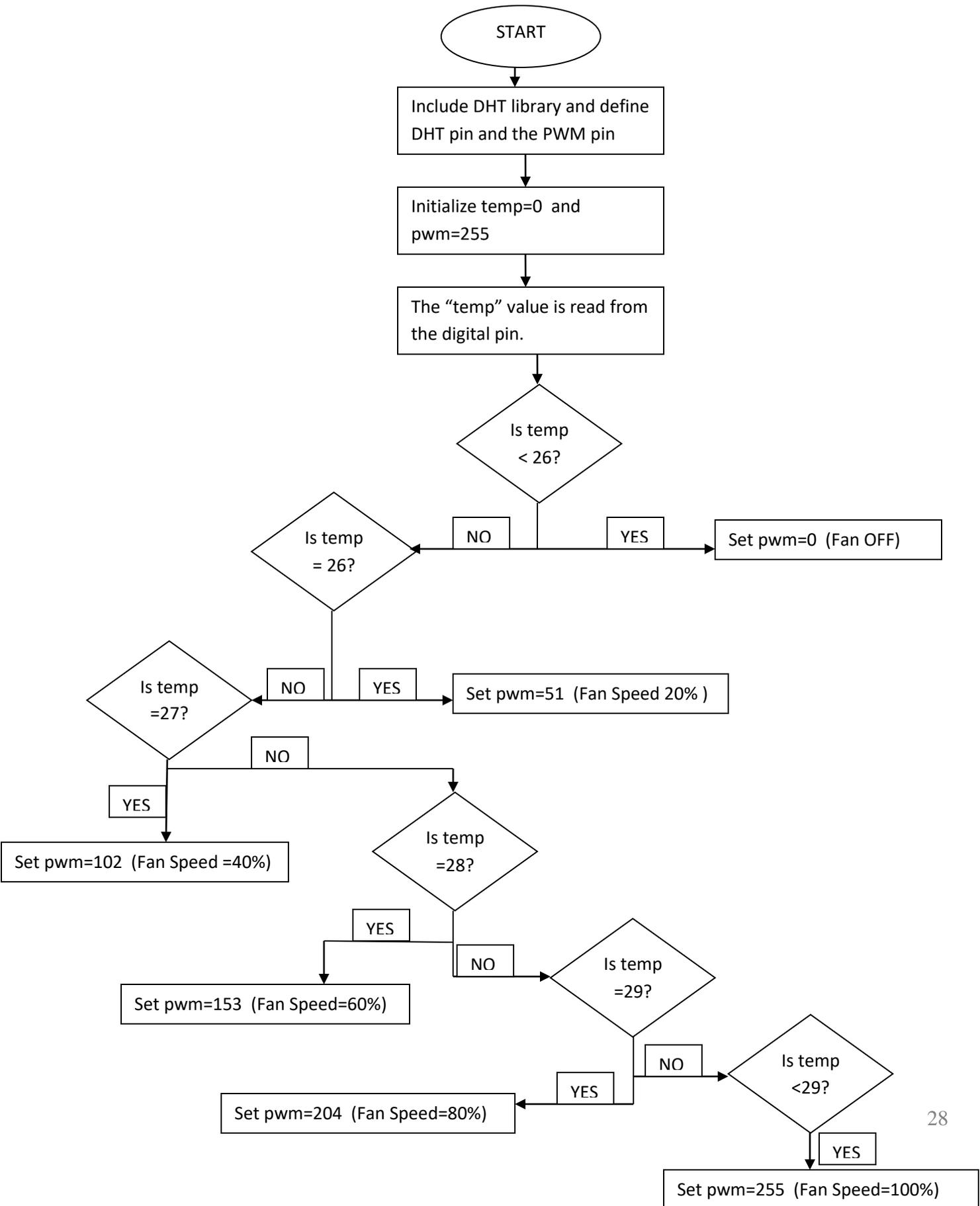


Fig 13: Connection of DHT11 with DC Fan

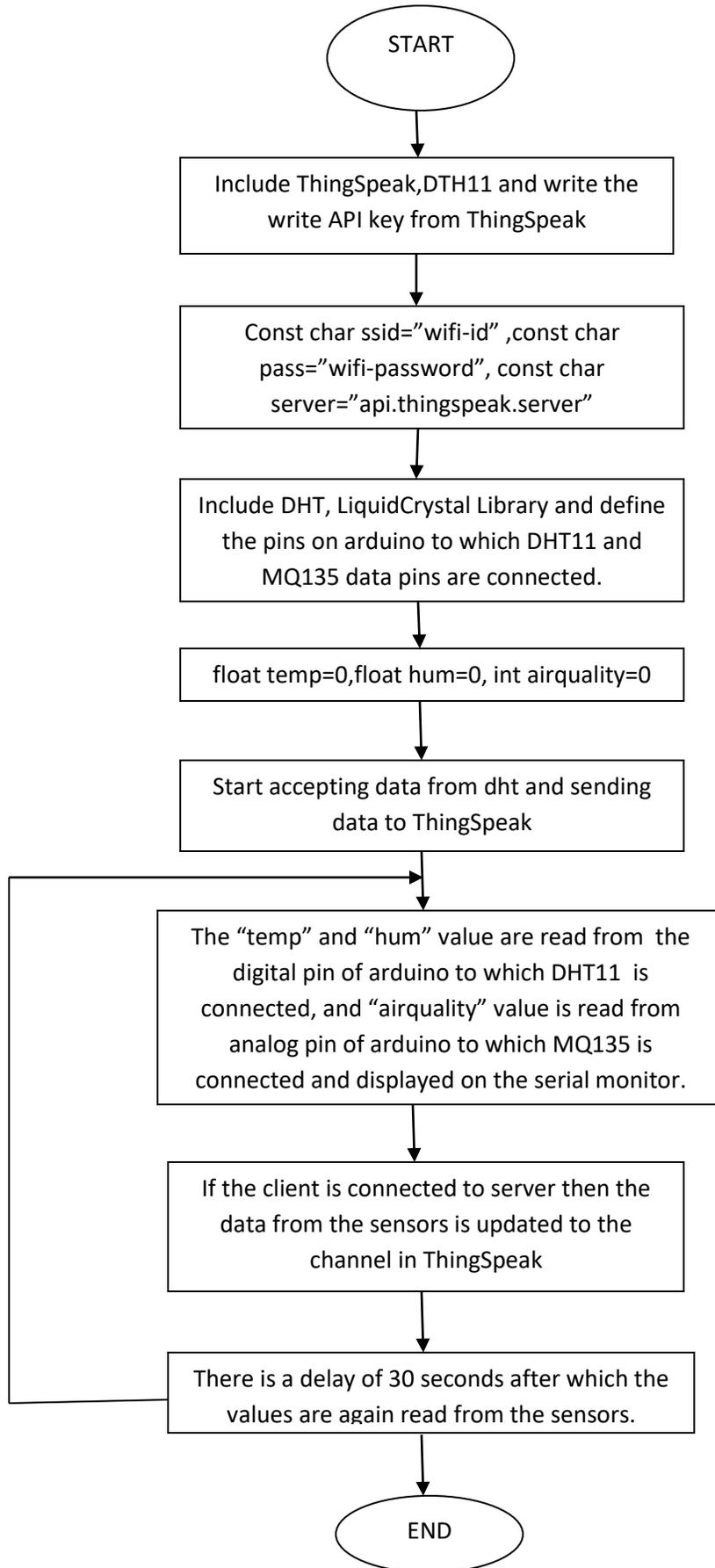
Flowchart for Displaying the Temperature, Humidity and Air Quality on LCD:



Flowchart for Controlling the Speed of Fan Based on Temperature:



Flowchart for Sending the Temperature, Humidity and Air Quality on THINGSPEAK:



Output:

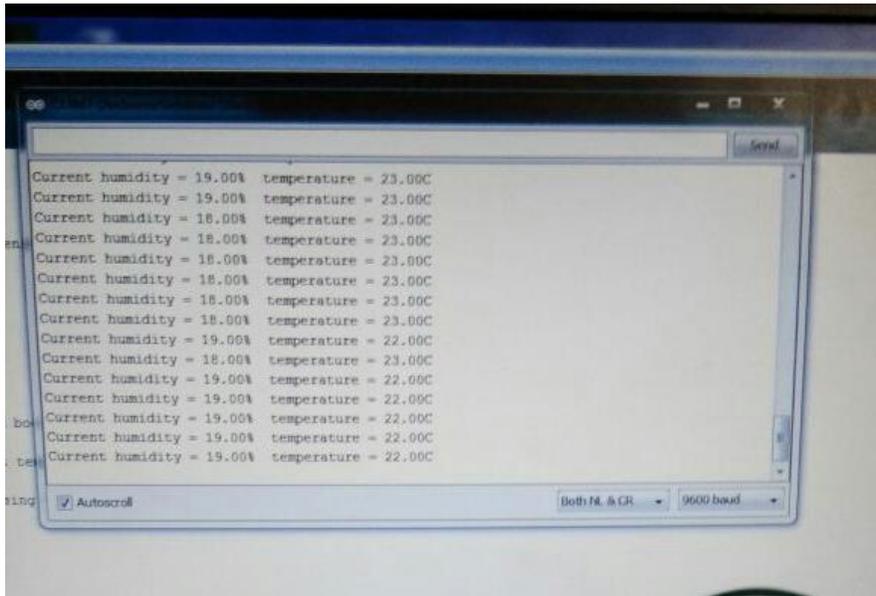


Fig 14: Output of DHT11 sensor (on Serial Monitor)

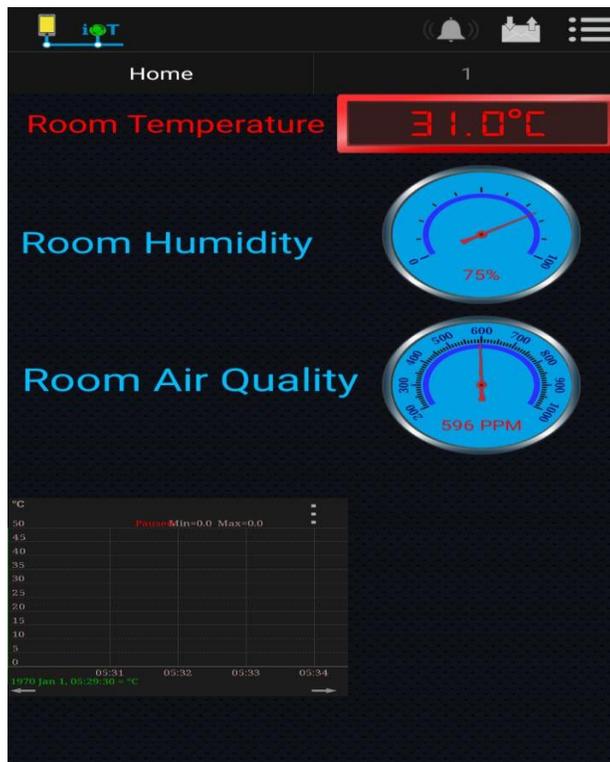


Fig 15: Output of DHT11 and MQ135 in THINGSPEAK app

Construction of Power Supply:

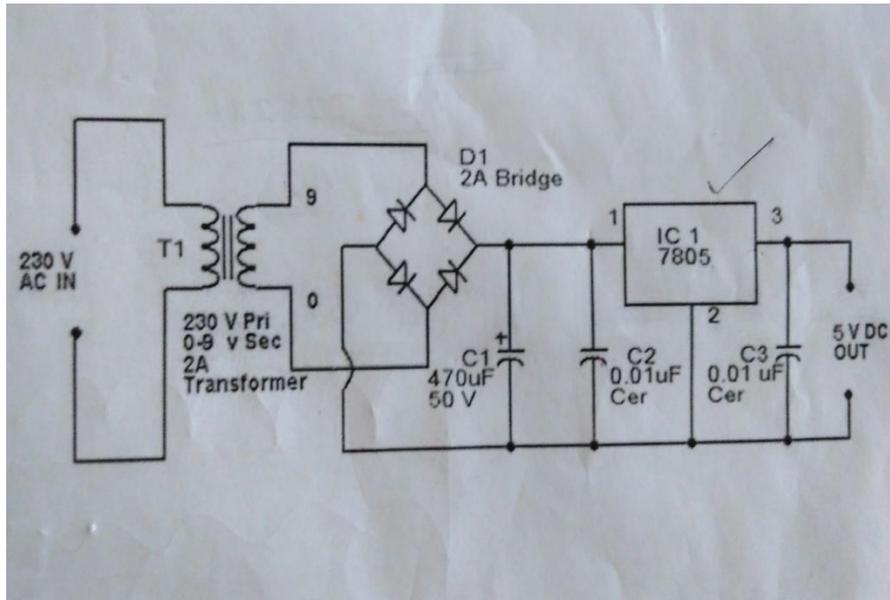


Fig 16: Circuit Diagram of 5V Regulated Power Supply

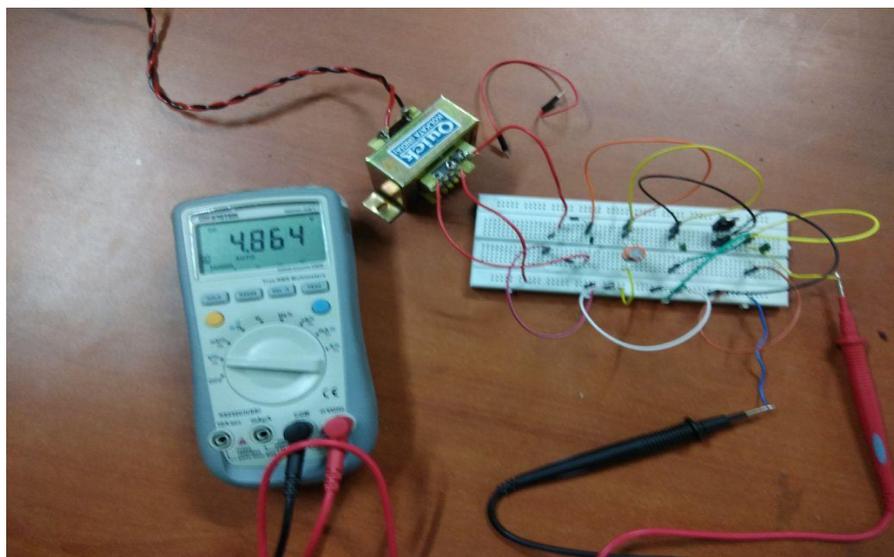


Fig 17: Connections of 5V Regulated Power Supply

ADVANTAGES:

- Sensors are easily available.
- Simple, compact, easy to handle.
- Sensors have long life and less cost.
- Quality of air can be checked indoor as well as outdoor.
- Detecting a wide range of physical parameters including temperature ,humidity and carbon dioxide.

APPLICATIONS:

- Indoor air quality monitoring.
- Industrial perimeter monitoring.
- Roadside pollution monitoring.
- To make this data available to common man.

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