Domestic water pump controller

A Project report submitted in partial fulfillment
of the requirements for the degree of B. Tech in Electrical Engineering

by

Sumedha Saha (11701619031)

Under the supervision of

Mr. Dipankar Santra
Assistant Professor
Department of Electrical Engineering

Department of Electrical Engineering
RCC INSTITUTE OF INFORMATION TECHNOLOGY
CANAL SOUTH ROAD, BELIAGHATA, KOLKATA – 700015, WEST BENGAL
Maulana Abul Kalam Azad University of Technology (MAKAUT)

Department of Electrical Engineering
RCC INSTITUTE OF INFORMATION TECHNOLOGY
CANAL SOUTH ROAD, BELIAGHATA, KOLKATA – 700015, WEST BENGAL
PHONE: 033-2323-2463-154, FAX: 033-2323-4668
Email: hodeercciit@gmail.com, Website: http://www.rcciit.org/academic/ee.aspx

CERTIFICATE

To whom it may concern

This is to certify that the project work entitled **Domestic water pump controller** is the bonafide work carried out by **SUMEDHA SAHA(11701619031),** a student of B.Tech in the Department of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India, during the academic year 2019-20, in partial fulfillment of the requirements for the degree of Bachelor of Technology in Electrical Engineering and that this project has not submitted previously for the award of any other degree, diploma and fellowship.

(Dr. Dipankar Santra)
Assistant Professor
Department of Electrical Engineering
RCC Institute of Information Technology

(Dr. Shilpi Bhattacharya Deb)
HOD, Electrical Engineering Dept
RCC Institute of Information Technology

Signature of the External Examiner
Name:
Designation:

ACKNOWLEDGEMENT

It is my great fortune that I have got opportunity to carry out this project work under the supervision of **Dr. Dipankar Santra** in the Department of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam Azad University of Technology (**MAKAUT**), West Bengal, India. I express my sincere thanks and deepest sense of gratitude to my guide for his constant support, unparalleled guidance, and limitless encouragement.

I wish to convey my gratitude to Prof. (Dr.) Shilpi Bhattacharya, HOD, Department of Electrical Engineering, RCCIIT and to the authority of RCCIIT for providing all kinds of infrastructural facility towards the research work.

I would also like to convey my gratitude to all the faculty members and staffs of the Department of Electrical Engineering, RCCIIT for their whole hearted cooperation to make this work turn into reality.

To

The Head of the Department
Department of Electrical Engineering
RCC Institute of Information Technology
Canal South Rd. Beliaghata, Kolkata-700015

Respected Madam,

In accordance with the requirements of the degree of Bachelor of Technology in the Department of Electrical Engineering, RCC Institute of Information Technology, I present the following thesis entitled "**Domestic water pump controller**." This work was performed under the valuable guidance of Dr. Dipankar Santra, Assistant Professor in the Dept. of Electrical Engineering.

I declare that the thesis submitted is my own, expected as acknowledge in the test and reference and has not been previously submitted for a degree in any other Institution.

Yours Sincerely,

SUMEDHA SAHA (11701619031)

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ABBREVIATIONS AND ACRONYMS

IC - Integrated Circuit
PCB – Printed Circuit Board
µC – Micro Controller
BJT - Bi-polar Junction Transistor
SPDT - Single Pole Double Throw
NO - Normally Open
NC - Normally Closed
COM – Common
LCD – Liquid Crystal Display
LED - Light Emitting Diode
POT – Potentiometer
SMPS – Switch Mode Power Supply
ISM – Industrial, scientific and medical
USB – Universal serial bus
SPI – Serial Peripheral Interface
I^2C – Inter-Integrated Circuit
GPIO – General Purpose Input Output
API–Application Program Interface

ABSTRACT

Domestic Water Level Monitoring & Control Using Ultrasonic sensor & NODE MCU is an amazing and very useful project. This project controls the water level in the tank by turning the water pump ON, when the water level is LOW, and turning the pump OFF when the water level is HIGH. Thus, the Node MCU based water level controller helps in preventing wastage of water in overhead tank.

In this project a transmitter circuit consists of an ultrasonic sensor to measure the water level in terms of distance. This data is sent to the microcontroller and a local OLED display is there to monitor the water level all the times. The controller is attached with a relay driver which further controls the water pump. The controller decides when the pump should be ON and OFF according the level of the water present in the overhead tank.

CHAPTER 1

(Introduction)

1.1 INTRODUCTION

In many industries, farms, hostels, hotels etc the process of water filling is done by an overhead tank, which is usually fed through an electric pump that needs to be switched off when the tank is filled up, and on when it becomes empty. Generally, tanks are filled by observing till it overflows the brim. Though there are losses involved in this process. These losses can be prevented if the tank is regulated automatically by incorporating a feed-back control mechanism, which would be capable of tripping the pump on or off as required. Though pumps with variable speed motors and commercially available water level sensors could be more efficient than on/off mechanisms. But these alternatives are more costly to procure and maintain.

Control systems can be classified into two parts as open loop and closed loop. In open loop systems a command is given to a system and it is assumed the system performs accordingly. Whereas a closed loop system compares the result or output of the system to a desired output and takes appropriate corrective actions. Thus, for their accurate performance closed loop systems are preferable. Here the sensor used is Ultrasonic sensor, it's a non-contact-based distance sensor. Due to the not contact properties of the sensor it can be used for any type of liquid taken in the tank and is more durable.

1.2 Ultrasonic Module HC-SR04

Figure 1: Ultrasonic Module (HC-SR04)

The ultrasonic sensor works on the principle of SONAR and RADAR system which is used to determine the distance of an object.

An ultrasonic sensor generates the high-frequency sound (ultrasound) waves. When this ultrasound hits the object, it reflects as echo which is sensed by the receiver as shown in below figure 2. By measuring the time required for the echo to reach to the receiver, we can

calculate the distance. This is the basic working principle of Ultrasonic module to measure distance.

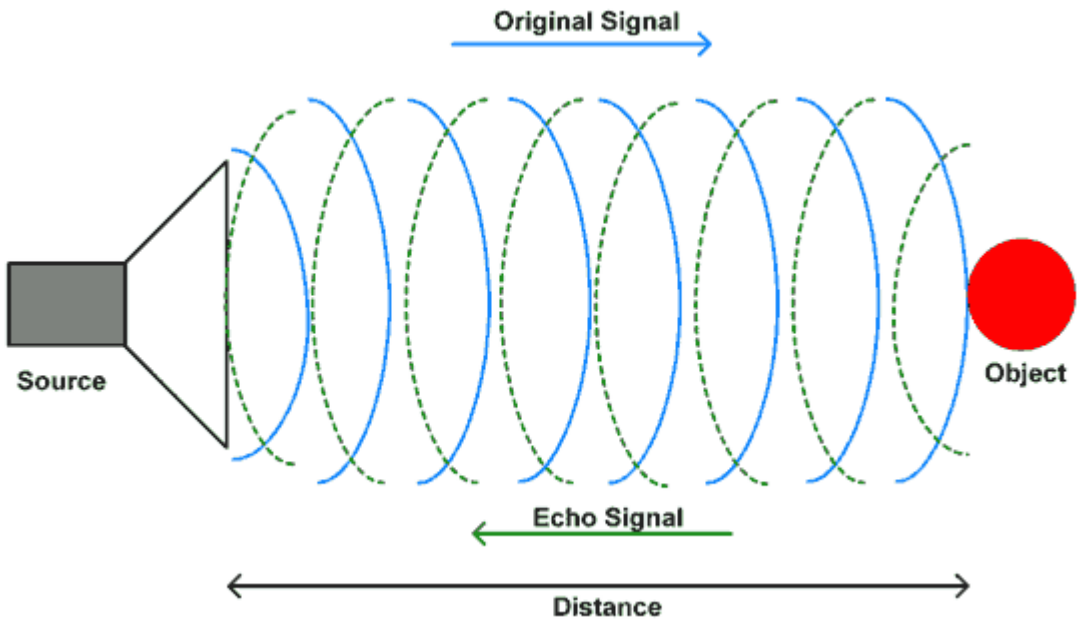


Figure 2: Ultrasonic Working Principle

1.3 HC-SR04 Ultrasonic Module Timing Diagram

1. We need to transmit trigger pulse of at least 10 us to the HC-SR04 Trig Pin.

2. Then the HC-SR04 automatically sends Eight 40 kHz sound wave and wait for rising edge output at Echo pin.

3. When the rising edge capture occurs at Echo pin, start the Timer, and wait for falling edge on Echo pin.

4. As soon as the falling edge is captured at the Echo pin, read the count of the Timer. This time count is the time required by the sensor to detect an object and return back from an object.

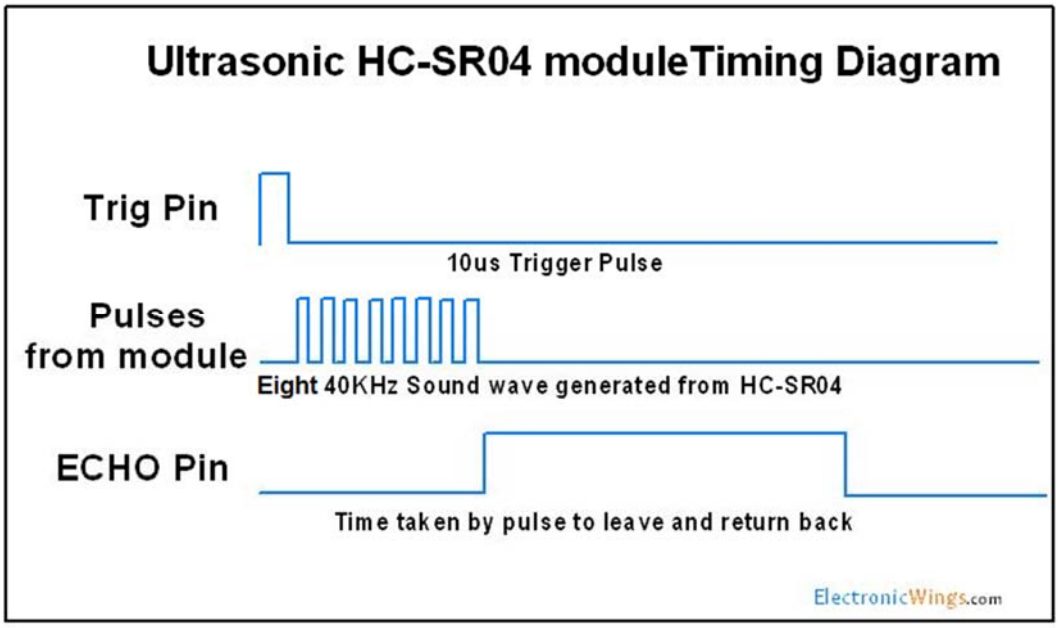


Figure 3: Ultrasonic Module Timing Diagram

1.4 Distance Calculation using HC SR 04

We know that,

Distance = Speed x Time

The speed of sound waves is 343 m/s.

So,

$$\text{Total Distance} = \frac{343 \text{ x Time of High(Echo) Pulse}}{2}$$

Total distance is divided by 2 because signal travels from HC-SR04 to object and returns to the module HC-SR-04.

1.5 Overview and benefits of the project

1.5.1 Advantages of Water Level Indicators & Float Switches

An automated water level controller is a sensible technique to monitor and regulate the water level in the tanks Apart from the obvious benefit of conserving water and using it wisely, there are several other noteworthy advantages including:

1.Conserves Energy:

Water level controllers that automatically adjust the water level save energy. They do it by automatically turning off the motor when the tank is full and when there is no water flow to the tank. This means that less water and energy are utilized to control a water supply. This is especially useful in today's world when energy conservation is a top priority.

2. Automatic

Another notable advantage with these devices is that they regulate on their own. Eliminating manual operations with a timer switch, the frustrations of manual monitoring water tanks are minimized. Water levels are maintained at the appropriate levels thanks to the automatic operations of these devices.

3. Money Saver

A water level controller helps save money by limiting the waste of water and electricity. These devices accurately regulate how much energy is used to protect against any unnecessary water/electricity usage. Over time, the money saved is quite substantial.

4. Water Maximization

On average, water pumps are used more during midday. A water level controller can maximize the water usage provided during midday while automatically lessening the water usage at night. This results in an appropriate level of water at all times being maintained, while providing you with the maximum use of your water at the appropriate times.

5. Reliable Electronic Design

Addressing the durability problems found in earlier designs, the solid-state electronics in the newer models help to eliminate them. Not only do they help to eliminate the durability issues, but they also create considerable savings of the life span of the unit with an advanced modular design. In order to minimize problem areas of these designs, the only moving parts are the relays. These relays are easily replaced and tested by any skilled operator or electrician while being an inexpensive part.

1.5.2 Applications & Uses of Water Level Indicator

The uses of a water level indicator include the following applications:

Can be used in water tanks to control water levels

- Automatically turn ON/OFF pumps
- Can be used in factories, commercial complexes, apartments, home,
- Fuel tank level gauging
- Oil tank level control

- High & low-level alarms
- Pool water level control
- Life station switches
- Leachate level control
- Cooling tower water level control
- Sewage pump level control
- Remote monitoring liquid
- Water level control
- Pump controller
- Stream level monitoring
- Sump pump
- Tsunami warning and sea level monitoring
- Process batch control & monitoring
- Irrigation control

1.6 Organisation of thesis

The thesis is organised into five chapters including the chapter of introduction. Each chapter is different from the other and is described along with the necessary theory required to comprehend it.

Chapter2 deals with the literature reviews. From this chapter we can see before our project who else works on this topic and how our project is different and advance from those projects.

Chapter 3 deals with the theory required to do the project. The basic of operation of HC SR 04 ultrasonic distance sensor and how to interface with node mcu microcontroller are described there.

Chapter 4 deals with the hardware modelling of the projects. The main features, photographs, step by step operation of the prototype, component listing and the hardware interfacing of the required components are described here.

Chapter 5 describes the operation of the prototype circuit. A flow chart is presented on the actions which describes the principle of operation of the prototype.

Chapter 6 concludes the work performed so far. The possible limitations in proceeding research towards this work are discussed. The future work that can be done in improving

the current scenario is mentioned. The future potential along the lines of this work is also discussed.

Chapter 7 References are listed in this chapter

Appendix A, B & C Hardware description, software coding and datasheets are listed here.

CHAPTER 2

(Literature Review)

[1] Charles A, "IOT BASED WATER LEVEL MONITORING SYSTEM USING LABVIEW", International Journal of Pure and Applied Mathematics, Volume 118 No. 20 2018, 9-14 ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version).

This paper illustrates a solution of water scarcity faced by many societies and world in 21st century. The proposed paper focused on IOT based monitoring system, implementation, management of water distribution in large areas. The monitoring system was implemented by Ultrasonic sensors and Node MCU. This is non-contact water level management. By the system, water is transferred to several tanks from the ground water or dam, there water is pumped to tanks by motors. Each pump connected to each tank by solenoid valves, used to control the water flow to each tanks. The solenoid valves get turned on by USB6009 (DAQ Assist) with LABVIEW. The main function of DAQ is sending digital pulses to get valves ON. Ultrasonic sensors that measures the distance of water level in the tank & the data is displayed in the IoT devices. The received date is sent to google cloud platform. We can also retrieve the data from the webpage that will display in LAB VIEW front panel. Network of sensors has been used to buffer efficient water circulations. The included NI-DAQmx driver and configuration utility simplify configuration and measurement.

[2] S. V. Manikanthan and T. Padmapriya "Recent Trends In M2m Communications In 4g Networks And Evolution Towards 5g", International Journal of Pure and Applied Mathematics, ISSN NO: 1314-3395, Vol115, Issue -8, Sep 2017.

Machine-to-Machine (M2M) communications involvemachines communicating with each other and exchanging information with remote servers, possibly over a cellular network infrastructure. Currently, in LTE-Advanced systems, themain focus has been on supporting massive deployment of lowcost devices, with enhanced radio access network coverage. One key requirement for supporting M2M in LTE is theavailability of low cost devices. Typical LTE devices havebeen designed to provide broadband services. For example,
the least capable LTE device, called Category-1 device, has 2receive antennas, RF bandwidth of 20 MHz, and can supportdata rates of 10 Mbps in the downlink and 5 Mbps in the uplink.One key requirement for supporting M2M in LTE is theavailability of low cost devices. Typical LTE devices havebeen designed to provide broadband services. For example, the least capable LTE device, called Category-1 device, has 2receive antennas, RF bandwidth of 20 MHz, and can supportIt is predicted that in 2020 the total number of connected
devices will be about 50 billion , almost double comparingto today's number.data rates of 10 Mbps in the downlink and 5 Mbps in theuplink.Machine-to-Machine communication, with its capability ofproviding diverse set of applications and services,

isconsidered to be a key technology enhancement for 4G LTEAdvancedsystems, and is anticipated to maintain itsdominance in 5G systems as well.

[3] Neena Mani, Sudeesh T.P, Vinu Joseph, Titto V.D, Shamnas P.S, "Design and Implementation of a Automated Water Level Indicator", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering 2014 Vol 3 Issue 2, February 2014.

Water level indicator is widely used in many industries and houses .In this paper a programmed microcontroller is the basic component for the water level indicator. ATmega 32A microcontroller is helps to indicate the level of water or any other conducting liquid.. With the help of anlcd display we can see all the level of the water contained in a tank or in any other vessels. A liquid level sensor (transistor circuit) detects the present level of the liquid in the tank in terms of the voltage across transistor and feeds it to the microcontroller and the microcontroller generates a corresponding output text which in then displayed in the LCD. If the water level is full, then the circuits beeps through the buzzer notifying that the water level is full.The circuit is divided into two parts. First one is the microcontroller section which is kept on the breadboard and second is the transmitter section and its base is kept inside the water tank.The collector terminals of each of these transistors are connected to a +5 volt level. The emitter terminals are connected to input pins of PORT A of the microcontroller. The microcontroller continuously monitors the state of each of these input pins.If the first pin, which is the one corresponding to the quarter level of the tank is high then LCD displays "quarter". If both the first and second pins are high, then LCD displays "half full". Similarly if the first three pins are high then we infer from the LCD that the water level is three quarters of the tank. Likewise a high on all four pins displays the message "full". Once the water tank is full, the buzzer produces a short audible sound warning the user to switch off the motor.

[4] Jadhav, G. J, "Design and Implementation of Advanced ARM Based Surveillance System using Wireless Communication, International Journal of Advance Research in Computer Science and Management Studies" Vol 2, 2014.

This proposed paper is focused on the notion of water level monitoring and management within the context of electrical conductivity of the water. More specifically, It illustrates investigation of the microcontroller based water level sensing and controlling in a wired and wireless environment. Water Level management approach would help in reducing the home power consumption and as well as water overflow.it can indicate the amount of water in the tank that can support Global Water types including cellular dataloggers, satellite data transmission systems for remote water monitoring system.At the first stage of design a water level sensor is been made for sensing water level accurately. Microcontroller is used to control the overall system automatically that reduces the design

and control complexity. Microcontroller takes input from the sensor unit which senses the water level through inverter. After processing input variables, resultant output decides the water pump's action (on/off) with respect to current water status of the tank.The main intension of this research work was to establish a flexible, economical and easy configurable system which can solve our water losing problem. We have been used a low cost PIC 16F84A microcontroller in this system which is the key point to reduce.

[5] Priya B. Patel, Viraj M. Choksi, Swapna Jadhav, M.B. Potdar, "Smart Motion Detection System using Raspberry Pi", International Journal of Applied Information Systems (IJAIS), Vol10 – No.5, February 2016.

The paper illustrates to make a smart surveillance system which can be monitored by owner remotely. As it is connected with the system with IOT, system will send the notifications when an intrusion is detected inside the room. It is required to develop and implement affordable low cost web-camera based surveillance system for remote security monitoring. Authorized user can access to their monitoring system remotely via internet with the use a mobile phone and monitor the situation on application. This project describes the use of low-cost single – board computer Raspberry Pi with wireless internet. This work is focused on developing a surveillance system that detects stranger and to response speedily by capturing and relaying images to admin office based wireless module and thus activate the alert system both at intruder location and office admin. Surveillance System consists of mainly two parts: A. Hard-wired surveillance systems: These systems use wires to connect the cameras, motion detectors, power supply and LAN cable with the pi., Remote Access Systems. 2. USB Camera, Raspberry Pi, Android device, PIR sensor whose sensitivity range up to 20 feet (6 meters) 110 degrees * 60 degrees.Softwares like Python,NOOBS, PUTTY, RASPBIAN OS are to be used.Therefore this kind of real time Surveillance system has great prospect of in building a secured digital world.

[6] S. M. Khaled Reza, Shah Ahsanuzzaman Md. Tariq, "Microcontroller Based Automated Water Level Sensing and Controlling: Design and Implementation Issue", Proceedings of the World Congress on Engineering and Computer Science 2010 Vol I WCECS 2010, October 20-22, 2010, San Francisco, USA.

This paper introduces the notion of water level monitoring and management within the context of electrical conductivity of the water. More specifically, It investigate the microcontroller based water level sensing and controlling in a wired and wireless environment.From the users perspective, it is required to reuse such valuable resource in a mobile application. Finally, It proposes a web and cellular based monitoring service protocol would determine and senses water level globally.To implement the system we should use some necessary parts such as PIC 16F84A microcontroller, Crystal Oscillator, 2 capacitor having capacitance 22 pF and 27 pF, inverter, LED, water tank, water level sensor, water pump, transistor, inductor and some capacitor should be implemented.

When the water is decreasing from the tank by home use, the display LED should start to become OFF one after another from the top to bottom. If all the LEDs becomes OFF that means the tank becomes empty again and the water pump should becomes automatically ON again exactly after the last LED becomes OFF. These operations should automatically perform as a cycle. This article focuses on displaying the available local connections and the stored remote connections through the internet&Designing interactive application software for remote PC or mobile should display data in table format or in the graphical interface for integration of the wireless water level monitoring.

[7] R. S. SUNMONU, M. A. SODUNKE, O. S. ABDULAI & E. A. AGBOOLA "DEVELOPMENT OF AN ULTRASONIC SENSOR BASED WATER LEVEL INDICATOR WITH PUMP SWITCHING TECHNIQUE", International Journal For Research In Electronics & Electrical Engineering ISSN: 2208-2735

The liquid levels determination is done by electronically converting the time of arrival of echo as recorded by the receiver (R) of the ultrasonic sensor from incident waves from transmitter (T). Arduino UNO, an active microprocessor in this design is commercially available which is electronically and mechanically fragile, hence the needs to replace Arduino UNO with rugged and cost effective fabricated units from available cheap components.This paper looks into the development and implementation of such a simple and cost effective feedback regulator for use in applications where there are needs to real timely monitor the water levels.The aim of this present work is to develop an independent water level control system with design based on ultrasonic transducer (sensor) thereby addressing problems of untimely response and frequent breakdown of contact sensors due to surface coating and corrosion from the water medium which characterized existing water level control based contact sensors. Our developed system controls, monitors and maintains the water level in the tank (overhead or surface) and ensures the continuous flow of water round the clock without the labor stress of manually switching the pump ON or OFF thereby saving time, electrical energy, water, and prevent overworking of the feed pump.Thenon contact ultrasonic sensor is strategically positioned on the peak of the vessel thereby solving the problems of frequent replacement of contact and submersible sensor which characterize existing commercial and expensive water indicator. The module detected, controlled and maintained the level of water. The level of the water in the vessel is indicated in % of the volume holding capacity of the tank which is displayed on the Liquid Crystal Display (LCD) unit.

CHAPTER 3

(Theory)

3.1 NODE MCU

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 from Espressif, and hardware which is based on the ESP12 module. The term "NodeMCU" by default refers to the firmware rather than the dev kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open-source projects, such as lua-cjson, and spiffs.

Figure 4: NODE MCU Development board

NodeMCU was created shortly after theESP8266 came out. On December 30, 2013, Espressiv system began production of the ESP8266. The ESP8266 is a Wi-Fi SoC integrated with a Tensilica Xtensa LX106 core, widely used in IoT applications.

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability produced by Shanghai-based Chinese manufacturer, Espressif Systems.

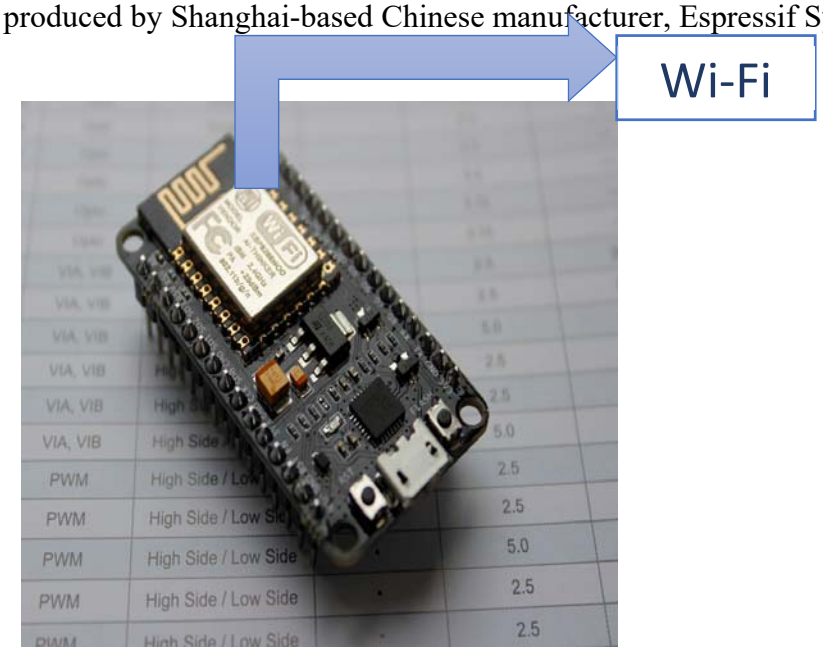


Figure 5: NODE MCU with inbuilt Wi-Fi module

3.1.1 Pin configuration of NODE MCU development board

This module provides access to the GPIO (General Purpose Input/Output) subsystem. All access is based on the I/O index number on the NodeMCU dev kits, not the internal GPIO pin. For example, the D0 pin on the dev kit is mapped to the internal GPIO pin 16.

Please refer to the below GPIO pin maps for the index↔gpio mapping.

Table 1: Node MCU index↔gpio mapping

IO index	ESP8266 pin	IO index	ESP8266 pin
0 [*]	GPIO16	7	GPIO13
1	GPIO5	8	GPIO15
2	GPIO4	9	GPIO3
3	GPIO0	10	GPIO1
4	GPIO2	11	GPIO9
5	GPIO14	12	GPIO10
6	GPIO12		

[*] D0(GPIO16) can only be used as GPIO read/write. No support for open-drain/interrupt/pwm/i2c

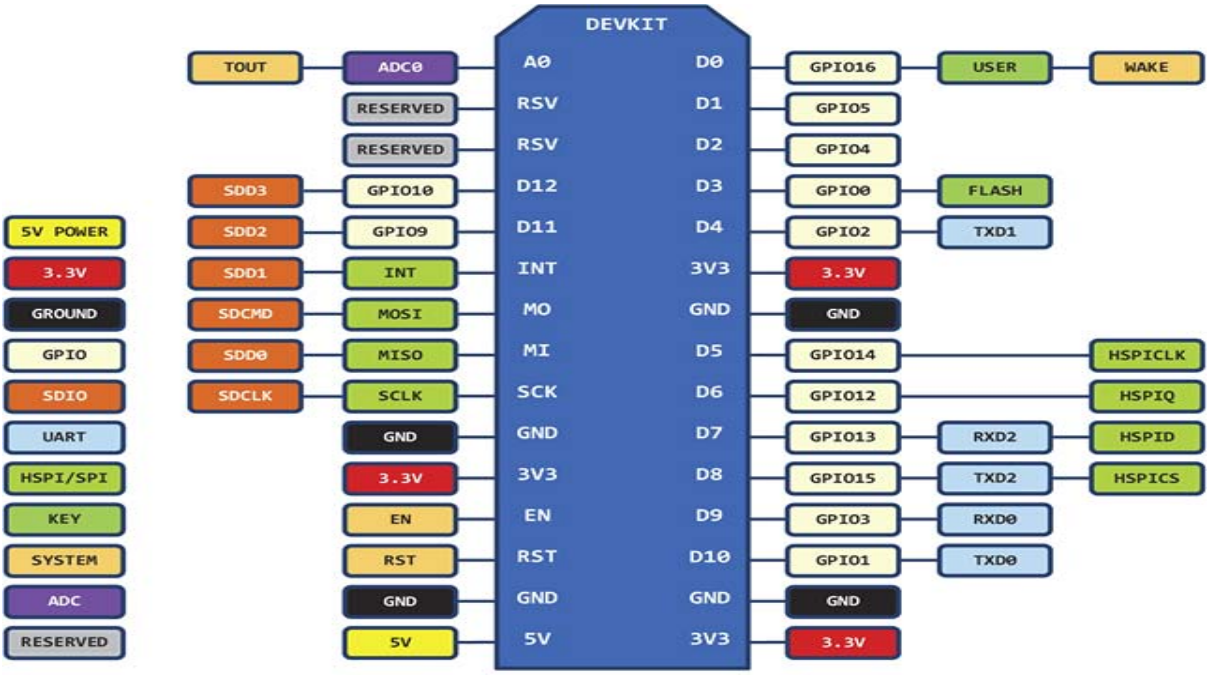


Figure 6: NODE MCU pin configuration

3.1.2 Installation of Node MCU & Coding

Mostly these days devices download and install drivers on their own, automatically. Windows does not know how to talk to the USB driver on the Node MCU so it cannot figure out that the board *is* a Node MCU and proceed normally.

- Node MCU Amica is a ESP8266 wifi Module based development board. It has got Micro USB slot that can be directly connected to the computer or other USB host devices. It has got 15X2 Header pins and a Micro USB slot, the headers can be mounted on breadboard and the micro-USB slot is for connection to USB host device that may be a computer. It has got CP2102 USB to serial converter.
- In order to install CP2102 (USB to Serial Converter), user will need to download the driver for the same.
- Once user downloaded drivers as per the proper operating system; the system has got connected with the node MCU.
- From the device manager of the computer note down the COM port allocated to the newly connected USB device i.e. the node MCU Amcia. This com port number will be required while using Node MCU Amica.

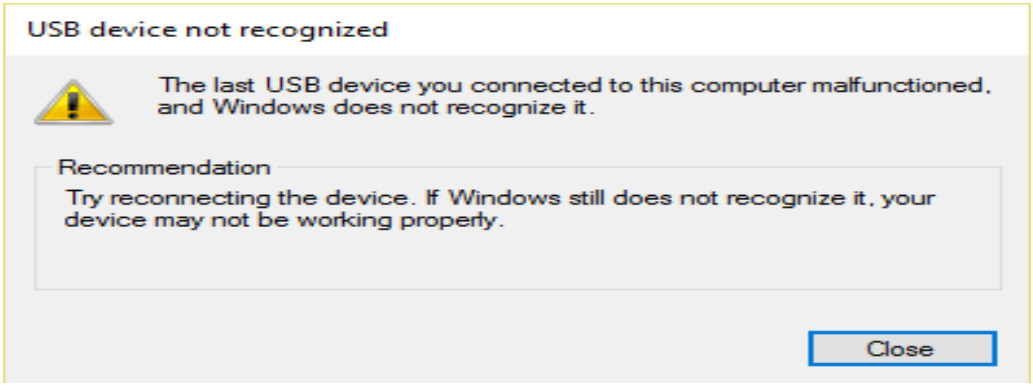


Figure 7: Snapshot of the installation process of NODE MCU

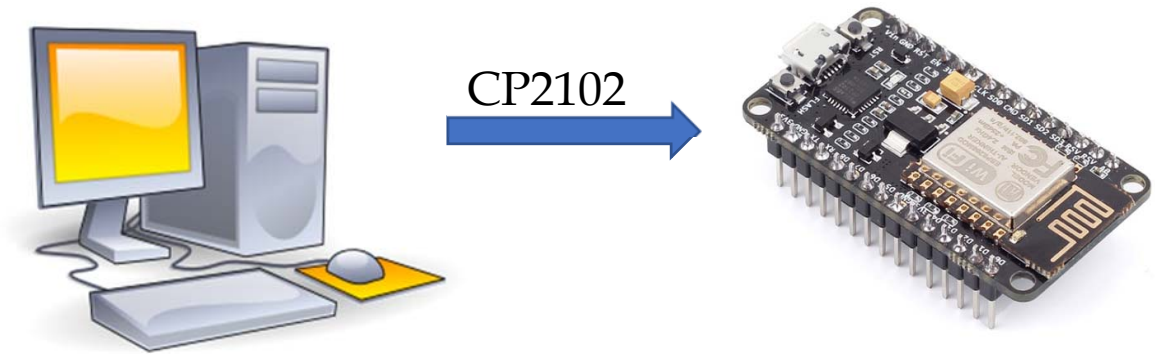


Figure 8: Driver Installation for NODE MCU

3.1.3 Interfacing of node mcu with arduino IDE

Firstly, open the Arduino IDE. Go to files and click on the preference in the Arduino IDE

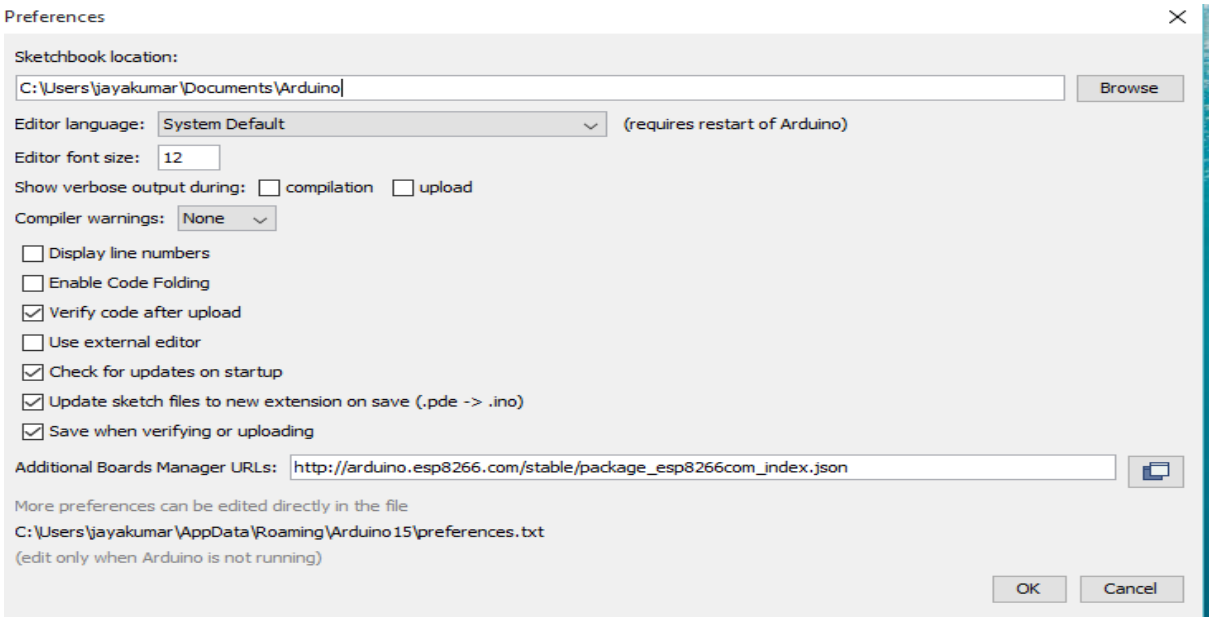


Figure 9: Arduino IDE preferences

copy the below code in the Additional boards Manager
http://arduino.esp8266.com/stable/package_esp8266com_index.json
click OK to close the preference Tab.

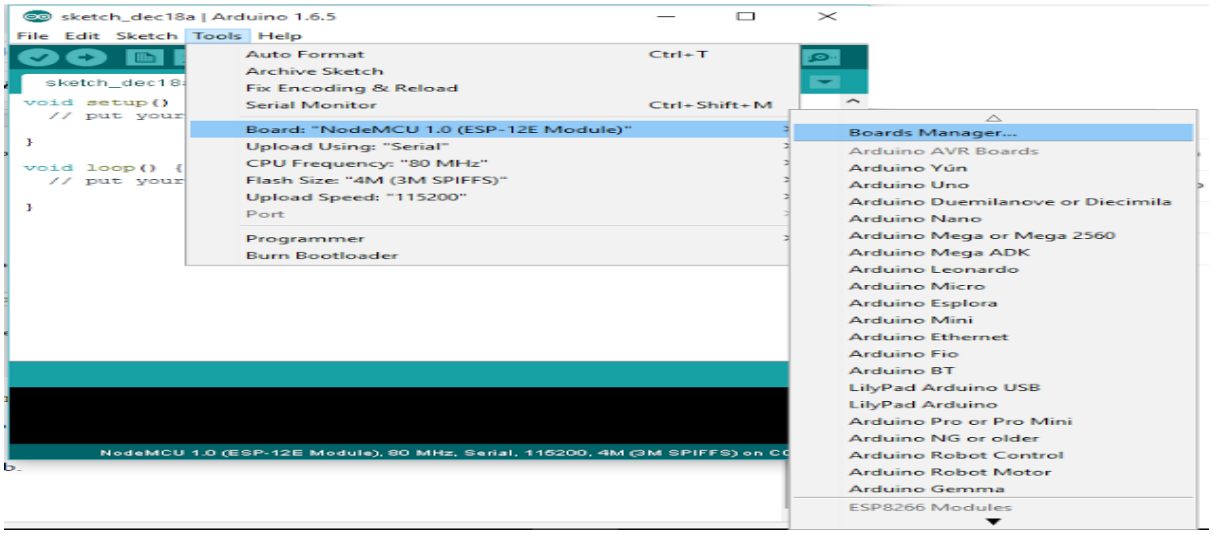


Figure 10: Arduino IDE board manager installation

After completing the above steps , go to Tools and board, and then select board Manager

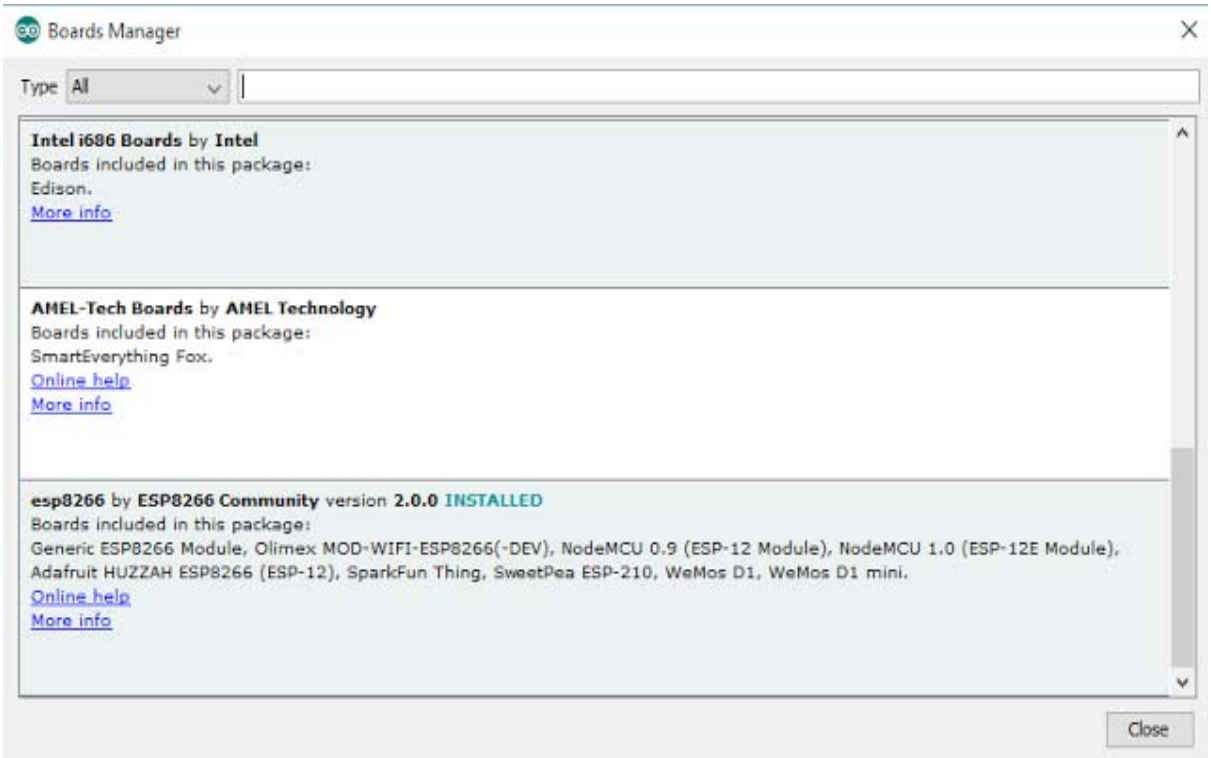


Figure 11: ESP 8266 board installation in Arduino

Navigate to esp8266 by esp8266 community and install the software for Arduino. Once all the above process had been completed, we are ready to program our esp8266 with Arduino IDE.

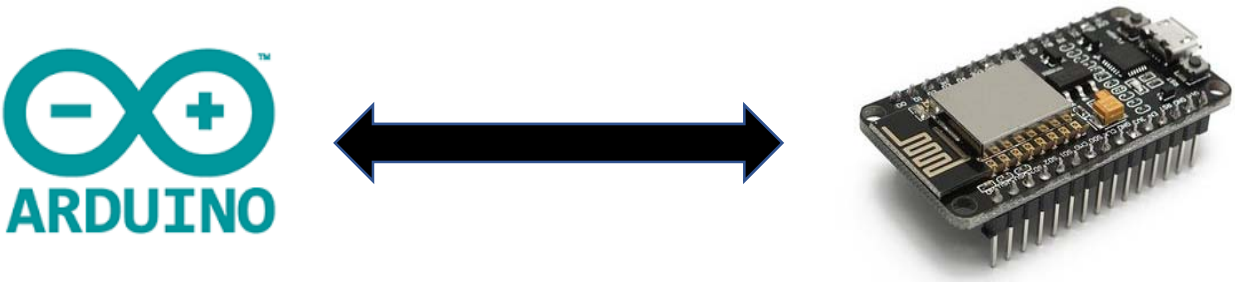


Figure 12: NODE MCU interfacing with Arduino

3.2 Ultrasonic Module HC-SR04

The ultrasonic sensor works on the principle of SONAR and RADAR system which is used to determine the distance to an object.

An ultrasonic sensor generates the high-frequency sound (ultrasound) waves. When this ultrasound hits the object, it reflects as echo which is sensed by the receiver as shown in below figure 1. By measuring the time required for the echo to reach to the receiver, we

can calculate the distance. This is the basic working principle of Ultrasonic module to measure distance.

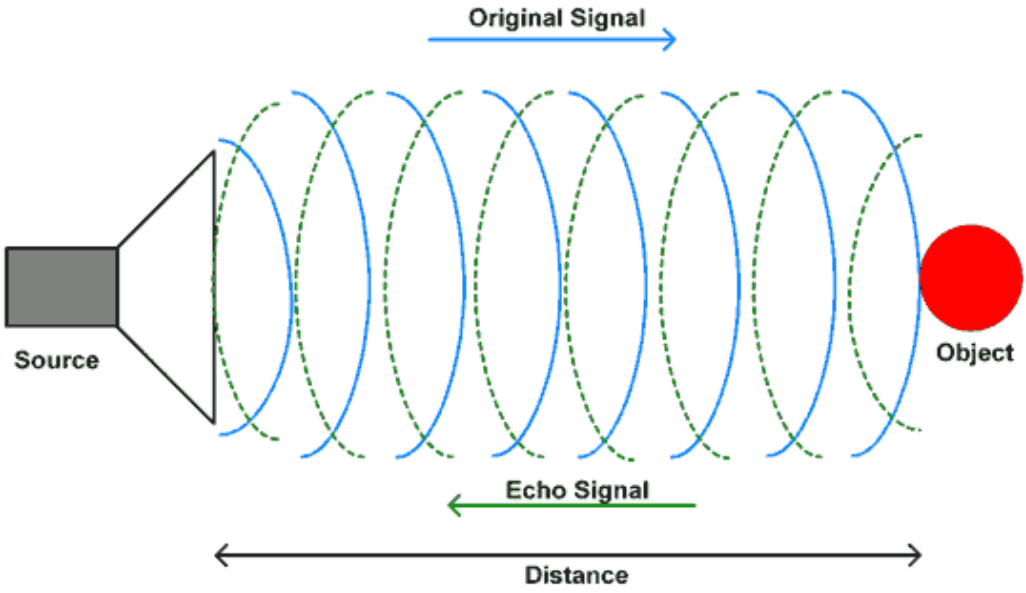


Figure 13: Ultrasonic Working Principle

3.2.1 HC-SR04 Ultrasonic Module Timing Diagram

1. We need to transmit trigger pulse of at least 10 us to the HC-SR04 Trig Pin.
2. Then the HC-SR04 automatically sends Eight 40 kHz sound wave and wait for rising edge output at Echo pin.
3. When the rising edge capture occurs at Echo pin, start the Timer and wait for falling edge on Echo pin.
4. As soon as the falling edge is captured at the Echo pin, read the count of the Timer. This time count is the time required by the sensor to detect an object and return from an object.

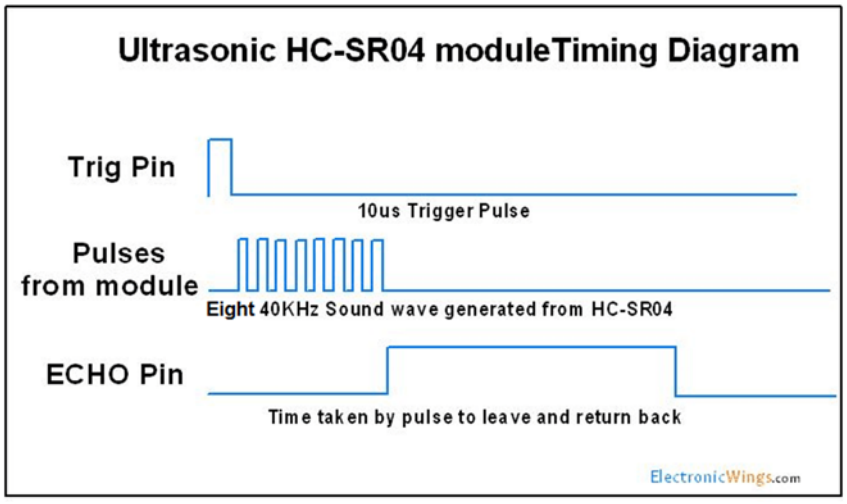


Figure 14: Ultrasonic Module Timing Diagram

3.2.2 Distance Calculation using HC SR 04

We know that,

Distance = Speed x Time

The speed of sound waves is 343 m/s.

So,

$$\text{Total Distance} = \frac{343 \text{ x Time of High(Echo) Pulse}}{2}$$

Total distance is divided by 2 because signal travels from HC-SR04 to object and returns to the module HC-SR-04.

3.2.3 Interfacing the Ultrasonic sensor with the microcontroller

Hcsr04 ultrasonic sensor is composed of ultrasonic transmitter, ultrasonic receiver and a control circuit. Hscr04 ultrasonic transmitter transmits ultrasound waves at 40,000 Hz. Transmitted waves bounce back if they hit any flat surface/object in their path. Bounced back waves reach the ultrasonic receiver. Ultrasonic receiver receives the bounced back waves and notifies the control circuit about it. Control circuit than calculates the time taken by waves to reach back after transmission. Time is than manipulated to approximate the distance travelled by waves or what is the distance between the sensor and the object? from which ultrasound waves bounced back.

Hcsr04 can measure distance between an active range of 2 cm to 4 meters. Hcsr04 requires 5 volts and 15 mA of power for operation. Hcsr04 has four pins. Two are power pins. Vcc is +ve pin apply 5v to this pin and Gnd is ground pin connect -ve of 5v power source with it. The other two pins are **Trigger** and **Echo**.

- **Trigger pin** is triggered by external controller to out burst an ultrasound wave.
- **Echo pin** notifies external controller when receiver receives back the bounced back wave.

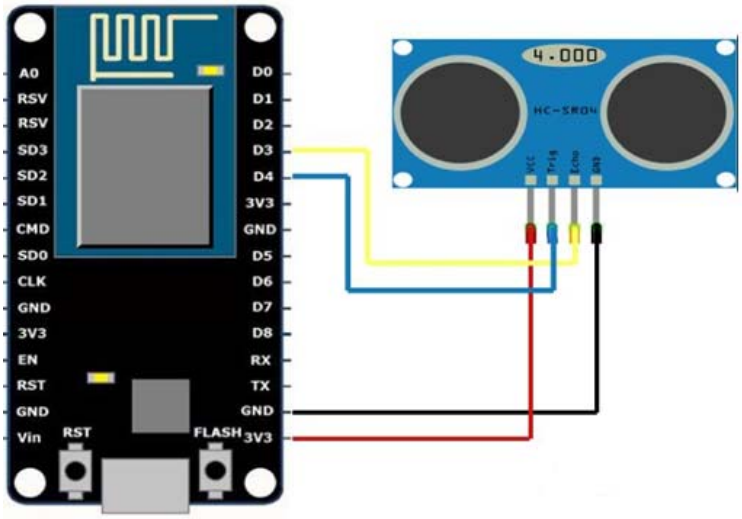


Figure 15: Interfacing HC SR 04 with NODE MCU

3.3 Connection Diagram

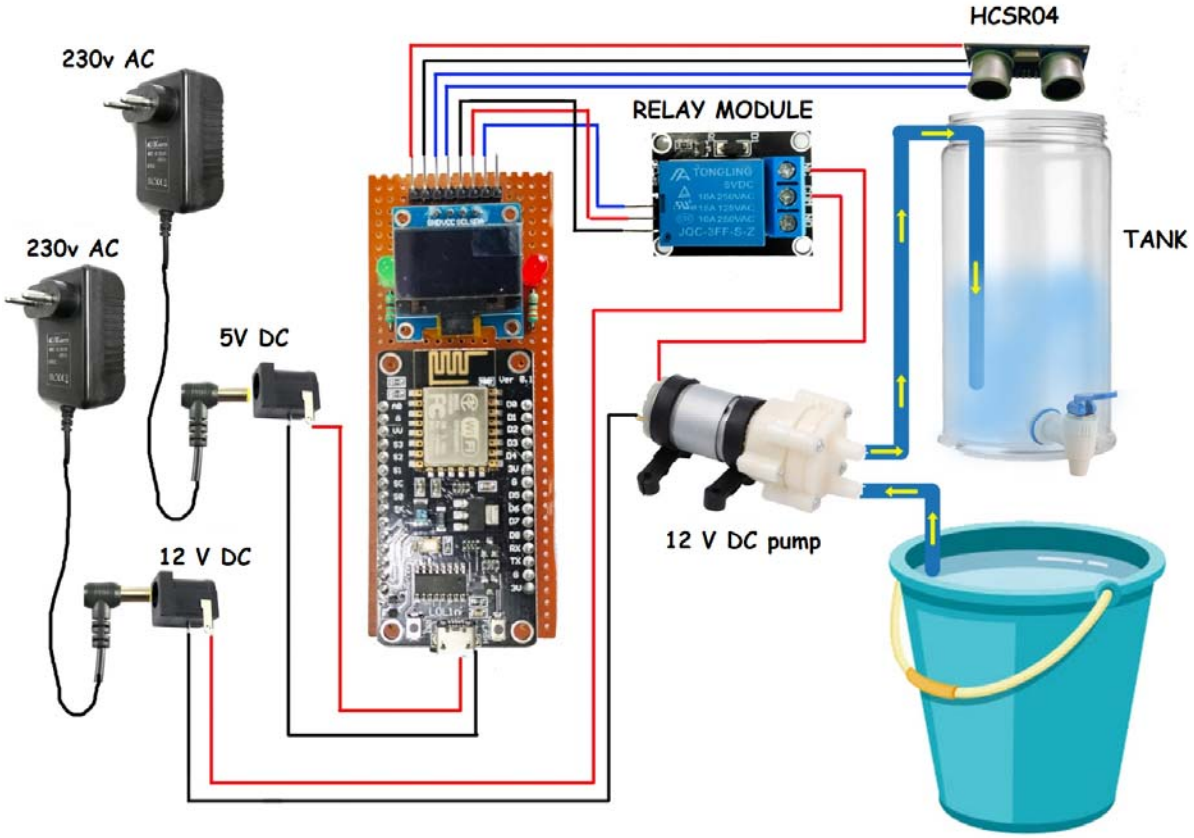


Figure 16: Connection diagram of the project

CHAPTER 4

(Hardware Modeling)

4.1 Main features of the prototype

The features of the developed prototype are:

- Automatic control of the water pump.
- Real time water level display in the onboard OLED.
- Static relay can handle the water pump easily (250-volt, 7 amp max, ON/OFF control)
- Maintain the water level to ensure all time availability of water
- Not contact sensor increases the life of the sensor
- Prevent water spillage to ensure SAVE WATER.
- 5 Volt operation (both control board and relay board)

4.2 Photographs of the prototype

Control Board:

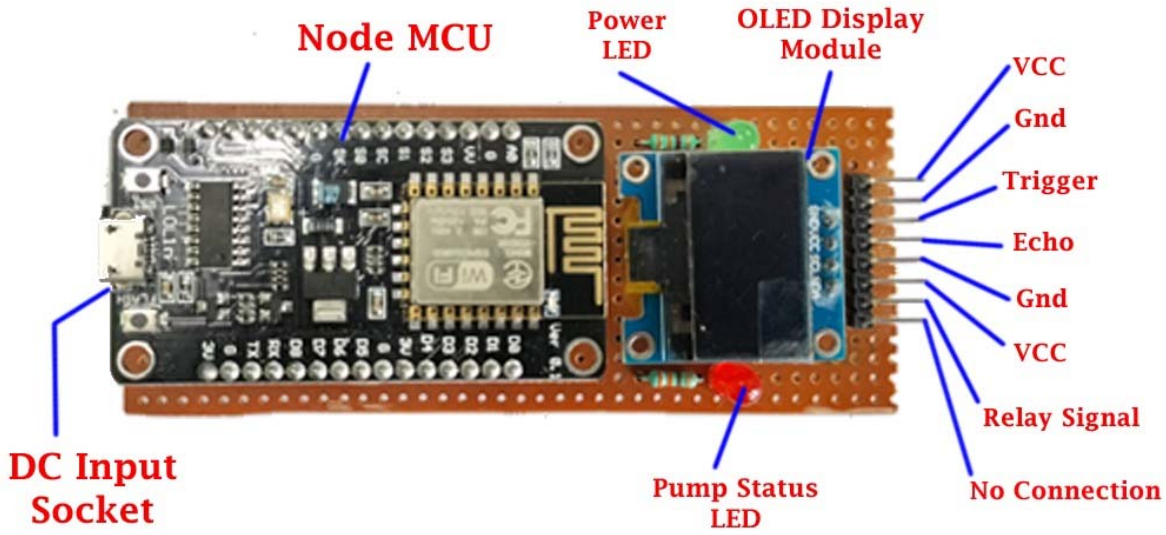


Figure 17: Main Controller board with OLED display module

4.3 Components required

Table 2: Component listing

SL.No.	Component	Qtn
1.	Node MCU	1
2.	Static Relay Module (5 v)	1
3.	0.96” OLED	1
4.	HC SR 04 (Ultrasonic sensor)	1
5.	12V DC pump	1
6.	330Ω Resistor	2
7.	5mm LED	2
8.	Single strand wire	2m
9.	Female PCB Header Connector	1
10.	DC Socket (PCB mount)	1
11.	5-volt DC adapter	1
12.	12-volt DC adapter	1

4.4 Hardware connection

4.4.1 HC SR 04 interfacing with NODE MCU

Hcsr04 ultrasonic sensor is composed of ultrasonic transmitter, ultrasonic receiver and a control circuit. Hscr04 ultrasonic transmitter transmits ultrasound waves at 40,000 Hz. Transmitted waves bounce back if they hit any flat surface/object in their path. Bounced back waves reach the ultrasonic receiver. Ultrasonic receiver receives the bounced back waves and notifies the control circuit about it. Control circuit then calculates the time taken by waves to reach back after transmission. Time is than manipulated to approximate the distance travelled by waves or calculate the distance between the sensor and the object from which ultrasound waves bounced back.

Hcsr04 can measure distance between an active range of 2 cm to 4 meters. Hcsr04 requires volts and 15 mA of power for operation. Hcsr04 has four pins. Two are power pins. Vcc is +ve pin apply 5v to this pin and Gnd is ground pin connect -ve of 5v power source with it. The other two pins are **Trigger** and **Echo**.

- **Trigger pin** is triggered by external controller to outburst an ultrasound wave.
- **Echo pin** notifies external controller when receiver receives back the bounced back wave.

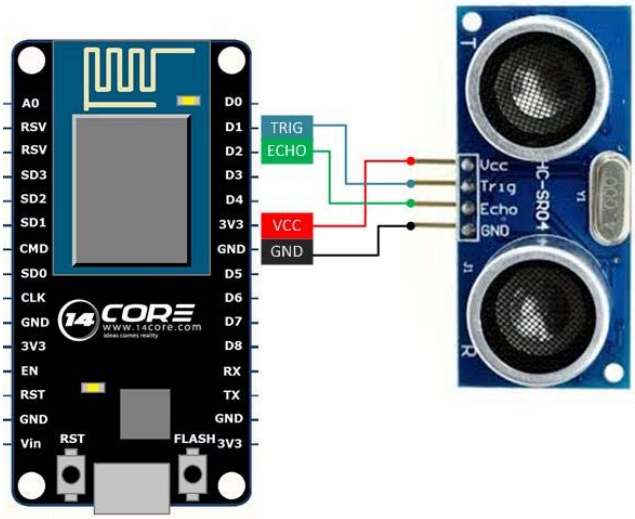


Figure 18: Interfacing HC SR 04 with NODE MCU

4.4.2 OLED Graphic Display Interfacing with NodeMCU

OLED Display Module

The OLED module shown in the figure 22 is a very popular module available in the market. There are many variants of this module available in market, having different resolutions, communication protocol or pixel colors. They do not require backlight since the display creates its own light. Hence, they consume less power. Both I2C and SPI based OLED modules are available in market.

A NodeMCU can communicate with this module using I2C communication protocol.

Pin Description

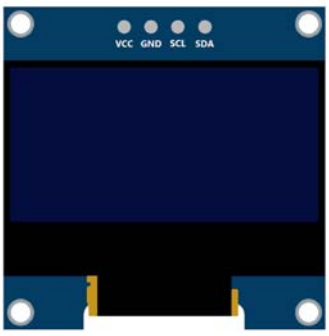


Figure 19: 128x64 I2C based OLED module

VCC: This is the power pin for the module. A supply of 3.3V or 5V can be provided to this pin to power the display.

GND: This is the ground pin for the module.

SCL and SDA: These are the serial clock and serial data pins for I2C Interface.

Interfacing Diagram

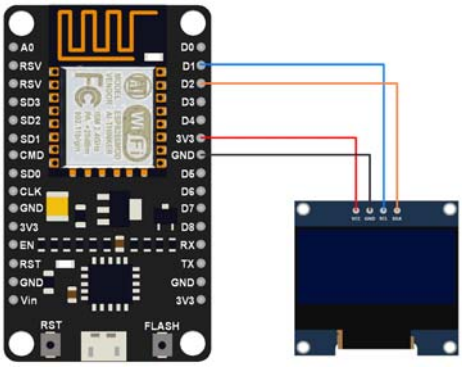


Figure 20: Interfacing OLED Display with NodeMCU

CHAPTER 5

(Logic & Operation)

5.1 INTRODUCTION

After assembling the system, what remains is to observe its operation and efficiency of the system. The total system is divided in several sub systems, like

- Node MCU Section
- HC SR04 Section
- OLED Section
- Relay Section

The operation of the whole circuit is depending on every sections performance.

5.2 Flow Chart

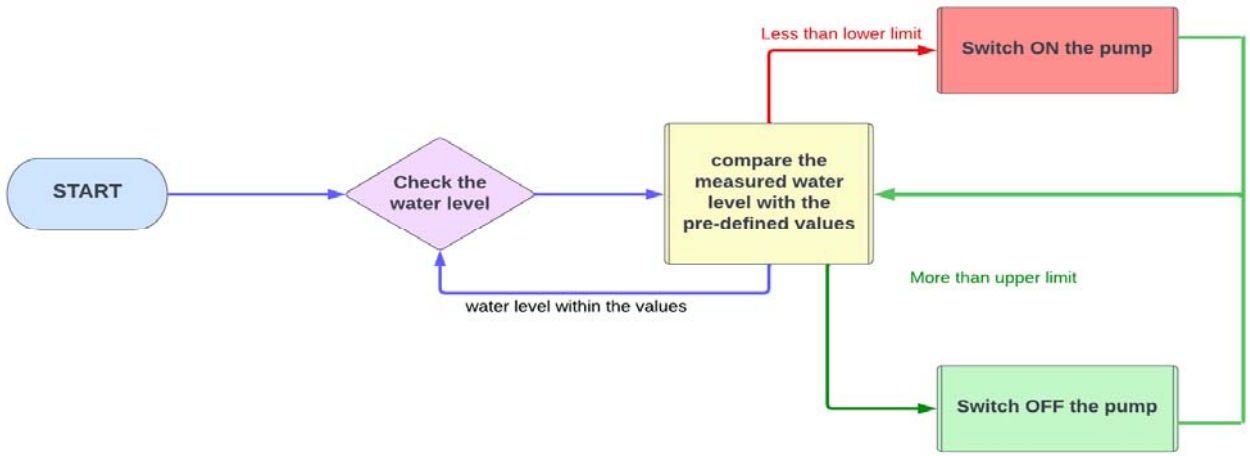


Figure 21: Flow chart of the program

5.3 Principle &Operations

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. It uses many open-source projects, such as lua-cjson, and spiffs.

5.3.1 Advantages of the NODE MCU

- ***Low cost:*** The Node MCU is less costlier than any other IOT based Devices. Because the wifi module which is used in it is of lowest cost.

- ***Hardware Part:*** It has Arduino Like hardware I/O. It is becoming very popular in these days that Arduino IDE has extended their software to work in the field of ESP 8266 Field module version.

- ***Network API:*** Node MCU has easily configurable network API.

- ***Integrated Wifi Module:*** ESP 8266 is incorporated in NODE MCU. It is an easily accessible WIFI module.

5.3.2 Disadvantages

- The operation of the circuit depends on the working internet connection. If the working internet connection is not available then it will not run.
- It also depends on the free server provided by the third party, if the free server is not working then it will not run.
- NODE MCU has less resources of official documentation

5.4 HC SR04 Ultrasonic sensors features

- Input Voltage: 5V
- Current Draw: 20mA (Max)
- Digital Output: 5V
- Digital Output: 0V (Low)
- Working Temperature: -15°C to 70°C
- Sensing Angle: 30° Cone
- Angle of Effect: 15° Cone
- Ultrasonic Frequency: 40kHz
- Range: 2cm - 400cm
- Dimensions
    - Length: 43mm
    - Width: 20mm
    - Height (with transmitters): 15mm
    - Centre screw hole distance: 40mm x 15mm
    - Screw hole diameter: 1mm (M1)
    - Transmitter diameter: 8mm

5.5 Cost estimation of the project

In this project we have used the cheapest IOT module NODE MCU. So the total cost of the project is reduced compare to the other IOT project. The total estimated cost of the complete project is listed in table 3.

Table 3: Costing of the projects

Sl. No.	Component	Cost
1.	HC SR 04	120
2.	NODE MCU	330
3.	Static Relay (5 volt)	30
4.	0.96” OLED	350
5.	12V DC Pump	180
7.	330 Ω Resistor	5
8.	5mm Led	4
10.	Single strand wire	30
12.	Female PCB Header Connector	8
15.	General Blank PCB (KS100)	40
Total		**1097/-**

5.6 Photographs of the prototype

Main Controller Board

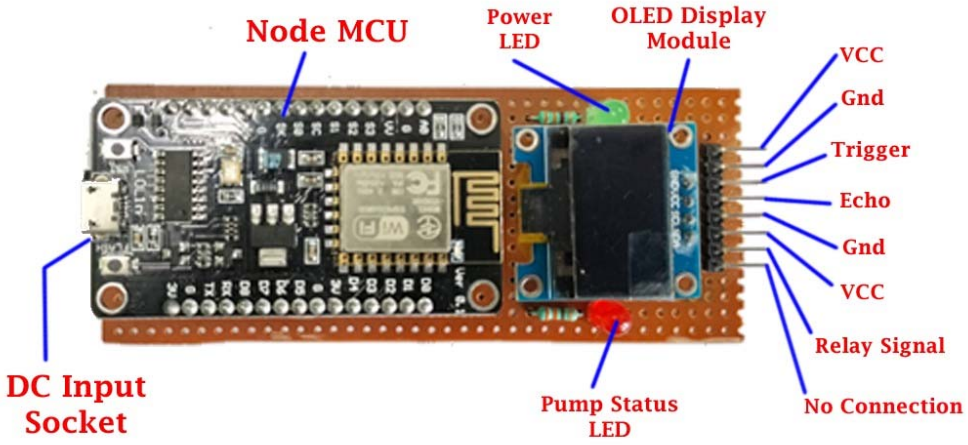


Figure 22: Main Controller Board

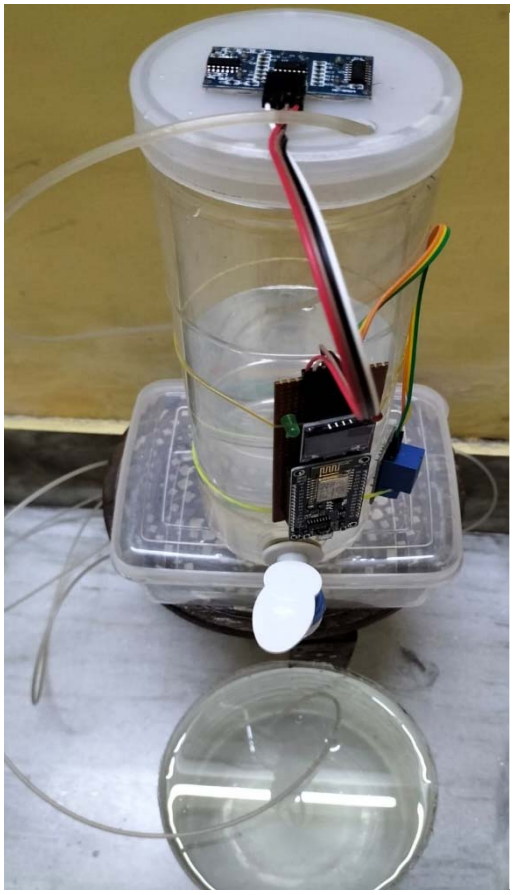


Figure 23: The whole prototype

Chapter 6

(Conclusion & Future Scope)

6.1 Conclusion

Here I developed a circuit which will control and monitor the water level of an overhead tank. It also prevents the wastage of water problem due to lack of proper monitoring in the home. It consists mainly following parts Node MCU, OLED, ultrasonic sensor (HC SR 04), relay module and water pump. The prototype will directly show the water level on OLED. The prototype continuously monitors the water level of the tank. Whenever the level goes below the predefined set limit, water pump will automatically start and if the water level crosses the upper limit of the tank, then the pump will automatically stop to prevent wastage of water.

6.2 Result

The experimental model was made according to the circuit diagram and the results were as expected. The OLED show the water level of an overhead tank as soon as it is power on. After proper monitoring it switches on/off water pump according to the situation.

6.3 Future work

- **Monitoring the lower reservoir level:**

In my project, I have used 12v DC water pump which is installed outside the reservoir, but there is no sensor or setup which can measure lower reservoir water level. If water is dried out or the water level becomes below the pump set up. Then pump would not be submerged in the lower water reservoir, diffuser could not suck the water by backward curved vanes. As a result, Motor may burn. So, this is the main limitation of our project.

- **Installing a water level monitoring app:**

A water monitoring app like Blynk app can be installed to properly monitor the tank water level through a smart phone. The level of the tank can be monitored continuously and the data can be sent to the user mobile through internet. The pump can be controlled anywhere using the internet.

- **Measuring the water quality:**

For the industry usage, when water pump will be allowed to uplift water from lower reservoir or local pond, river, then mud, sand, pebbles, household junks, wastes, plastics can block the water pipe attached with the motor. So, we must check the basic quality of water by **Turbidity sensors.** It measures the amount of light that is scattered by the suspended solids in water. As the amount of total suspended solids (TSS) in water increases, the water's **turbidity** level (and cloudiness or haziness) increases. On another hand, ph. meter is also used to make sure of the acidity of the water.

- **Measuring the water temperature**

Hot water can harm the valves, vanes, and pumps efficiency. Some thermocouple sensors or thermistors can measure the lower-level reservoirs water temperature. The thermocouple is prepared by two dissimilar metals which generate the electrical voltage indirectly proportional to change the **temperature**. By this process, I can implement some IoT devices to show temp data in both upper and lower reservoir and upload it in the server.

- **Including the rain water storage**

By 2025 about 30-40% of the world will have water scarcity, and according to the researchers, climate change can make this even worse. By 2025, an estimated 1.8 billion people will live in areas plagued by water scarcity, with two-thirds of the world's population living in water-stressed regions. Collecting **rainwater** has many advantages. When **harvesting rainwater** on a slope or hill, it can prevent soil erosion caused by water runoff after heavy rains. **Rainwater harvesting** structures are easy to build, do not require expensive materials and are low-maintenance. So distilled water saving is very necessary. Rain water is the huge source of it. So, my future plan is to make a rain water reservoir for additional purpose.

Chapter 7

(References)

[1] Charles A, “IOT BASED WATER LEVEL MONITORING SYSTEM USING LABVIEW”, International Journal of Pure and Applied Mathematics, Volume 118 No. 20 2018, 9-14 ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version).

[2] S.V.Manikanthan and T.Padmapriya “Recent Trends In M2m Communications In 4g Networks And Evolution Towards 5g”, International Journal of Pure and Applied Mathematics, ISSN NO:1314-3395, Vol115, Issue -8, Sep 2017.

[3] Neena Mani, Sudeesh T.P, Vinu Joseph, Titto V.D, Shamnas P.S, “Design and Implementation of a Automated Water Level Indicator”, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering 2014 Vol 3 Issue 2, February 2014.

[4] Jadhav, G. J, “Design and Implementation of Advanced ARM Based Surveillance System using Wireless Communication, International Journal of Advance Research in Computer Science and Management Studies”Vol 2,2014.

[5] Priya B. Patel, Viraj M. Choksi, Swapna Jadhav, M.B. Potdar, “Smart Motion Detection System using Raspberry Pi”, International Journal of Applied Information Systems (IJAIS), Vol10 – No.5, February 2016.

[6] S. M. Khaled Reza, Shah Ahsanuzzaman Md. Tariq, “Microcontroller Based Automated Water Level Sensing and Controlling: Design and Implementation Issue”, Proceedings of the World Congress on Engineering and Computer Science 2010 Vol I WCECS 2010, October 20-22, 2010, San Francisco, USA.

[7] R. S. SUNMONU, M. A. SODUNKE, O. S. ABDULAI & E. A. AGBOOLA “DEVELOPMENT OF AN ULTRASONIC SENSOR BASED WATER LEVEL INDICATOR WITH PUMP SWITCHING TECHNIQUE”,International Journal For Research In Electronics & Electrical Engineering ISSN: 2208-2735

Appendix A

(Hardware description)

Transformer less AC to DC power supply circuit using dropping capacitor

Production of low voltage DC power supply from AC power is the most important problem faced by many electronics developers and hobbyists. The straight forward technique is the use of a step-down transformer to reduce the 230 V or 110V AC to a preferred level of low voltage AC. But *SMPS* power supply comes with the most appropriate method to create a low-cost power supply by avoiding the use of bulky transformer. This circuit is so simple and it uses a voltage dropping capacitor in series with the phase line. Transformer less power supply is also called as capacitor power supply. It can generate 5V, 6V, 12V 150mA from 230V or 110V AC by using appropriate zener diodes.

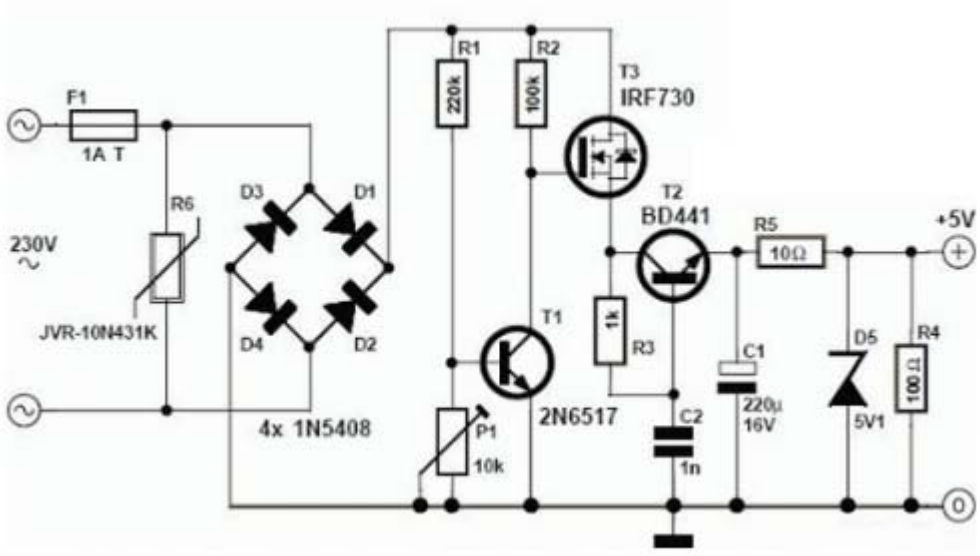


Figure 24: Transformer less SMPS 5 volt power supply

Working of Transformer less capacitor power supply

- This transformer less power supply circuit is also named as capacitor power supply since it uses a special type of AC capacitor in series with the main power line.
- A common capacitor will not do the work because the mains spikes will generate holes in the dielectric and the capacitor will be cracked by passing of current from the mains through the capacitor.
- X rated capacitor suitable for the use in AC mains is vital for reducing AC voltage.
- A X rated dropping capacitor is intended for 250V, 400V, 600V AC. Higher voltage versions are also obtainable. The dropping capacitor is non polarized so that it can be connected any way in the circuit.

- The 470kΩ resistor is a bleeder resistor that removes the stored current from the capacitor when the circuit is unplugged. It avoids the possibility of electric shock.
- Reduced AC voltage is rectified by bridge rectifier circuit. We have already discussed about bridge rectifiers. Then the ripples are removed by the 1000µF capacitor.
- This circuit provides 24 volts at 160 mA current at the output. This 24 volt DC can be regulated to necessary output voltage using an appropriate 1 watt or above zener diode.
- Here we are using 6.2V zener. You can use any type of zener diode in order to get the required output voltage.

Resistor

Figure 25: Resistor

Resistance is the opposition of a material to the current. It is measured in Ohms Ω. All conductors represent a certain amount of resistance, since no conductor is 100% efficient. To control the electron flow (current) in a predictable manner, we use resistors. Electronic circuits use calibrated lumped resistance to control the flow of current. Broadly speaking, resistor can be divided into two groups viz. fixed & adjustable (variable) resistors. In fixed resistors, the value is fixed & cannot be varied. In variable resistors, the resistance value can be varied by an adjuster knob. It can be divided into (a) Carbon composition (b) Wire wound (c) Special type. The most common type of resistors used in our projects is carbon type. The resistance value is normally indicated by color bands. Each resistance has four colors, one of the band on either side will be gold or silver, this is called fourth band and indicates the tolerance, others three band will give the value of resistance (see table). For example if a resistor has the following marking on it say red, violet, gold. Comparing these colored rings with the color code, its value is 27000 ohms or 27 kilo ohms and its tolerance is ±5%. Resistor comes in various sizes (Power rating).The bigger the size, the more power rating of 1/4 watts. The four color rings on its body tells us the value of resistor value.

Color Code of the resistor

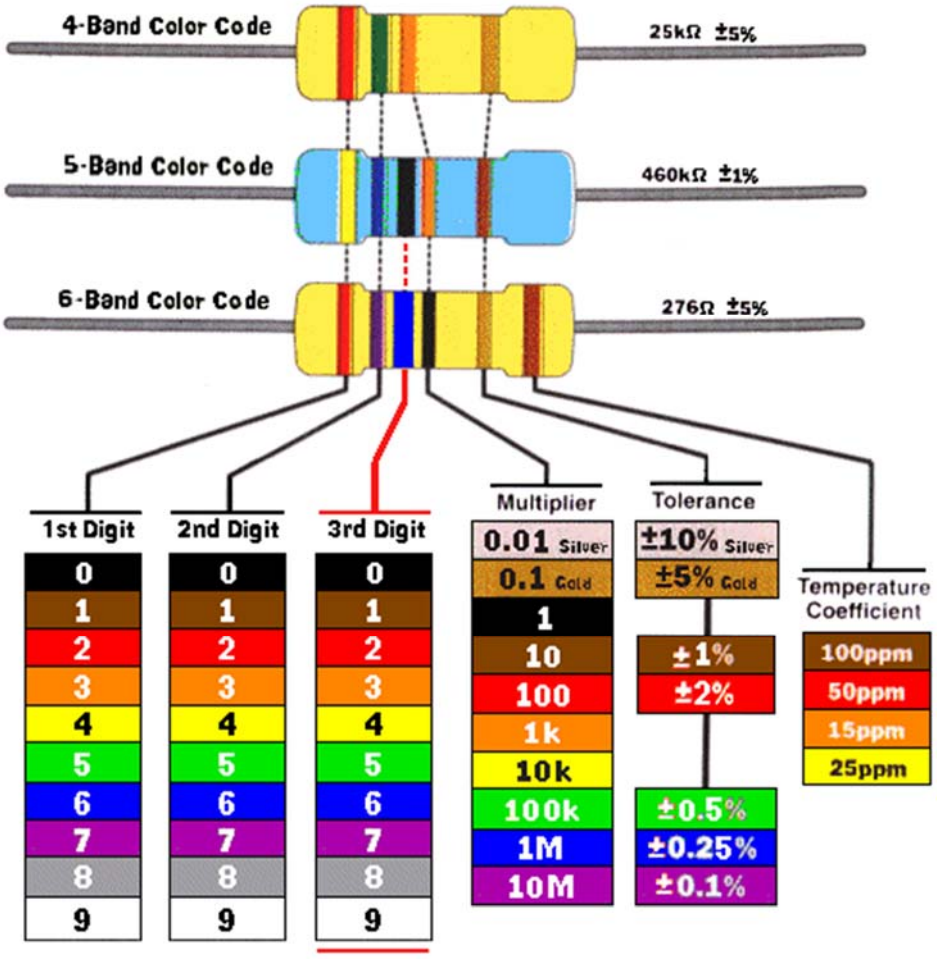


Figure 26: Color Code for resistance

OLED

An organic light-emitting diode (OLED) is a light-emitting diode (LED) in which the emissive electroluminescent layer is a film of organic compound that emits light in response to an electric current. This organic layer is situated between two electrodes; typically, at least one of these electrodes is transparent. OLEDs are used to create digital displays in devices such as television screens, computer monitors, portable systems such as smart phones, handheld game consoles and PDAs. A major area of research is the development of white OLED devices for use in solid-state lighting applications.

Figure 27: 128X64 OLED Module

NodeMCU

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. It uses many open source projects, such as lua-cjson and SPIFFS.

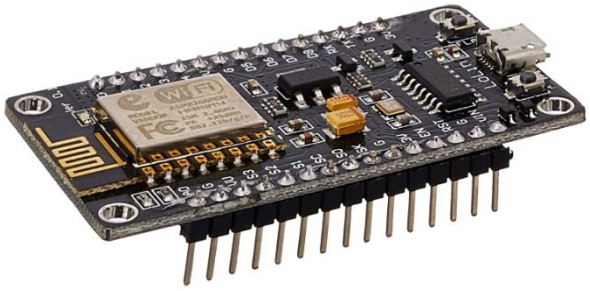


Figure28: Node MCU Module

Blank PCB

A **printed circuit board** (**PCB**) mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non-conductive substrate. PCBs can be *single sided* (one copper layer), *double sided* (two copper layers) or *multi-layer* (outer and inner layers). Multi-layer PCBs allow for much higher component density. Conductors on different layers are

connected with plated-through holes called vias. Advanced PCBs may contain components - capacitors, resistors or active devices - embedded in the substrate.

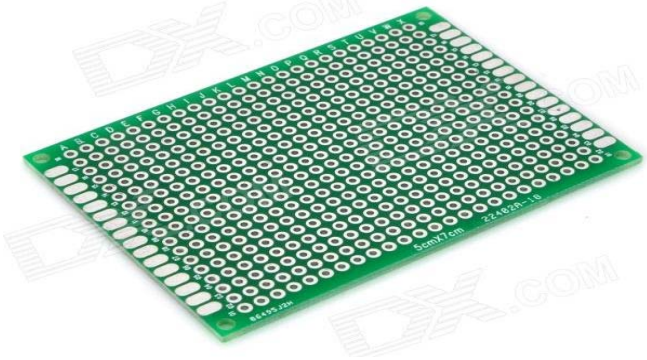


Figure 29: Blank glass epoxy PCB Board

FR-4 glass epoxy is the primary insulating substrate upon which the vast majority of rigid PCBs are produced. A thin layer of copper foil is laminated to one or both sides of an FR-4 panel. Circuitry interconnections are etched into copper layers to produce printed circuit boards. Complex circuits are produced in multiple layers.

Printed circuit boards are used in all but the simplest electronic products. Alternatives to PCBs include wire wrap and point-to-point construction. PCBs require the additional design effort to lay out the circuit, but manufacturing and assembly can be automated. Manufacturing circuits with PCBs is cheaper and faster than with other wiring methods as components are mounted and wired with one single part. Furthermore, operator wiring errors are eliminated.

Appendix B

(Software coding)

PROGRAM CODE:

```
#include <SPI.h>
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels
// Declaration for an SSD1306 display connected to I2C (SDA, SCL pins)
#define OLED_RESET     -1 // Reset pin # (or -1 if sharing Arduino resetpin)
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);


#define TRIGGERPIN D4
#define ECHOPIN    D5
#define PUMP       D8

long duration, distance, distance1;
float percentage;

void setup()
{
  // Debug console
  Serial.begin(115200);
  if (!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
    Serial.println(F("SSD1306 allocation failed"));
    for (;;); // Don't proceed, loop forever
  }
  display.clearDisplay();

  // Debug console
  Serial.begin(115200);
  pinMode(TRIGGERPIN, OUTPUT);
  pinMode(ECHOPIN, INPUT);
  pinMode(PUMP, OUTPUT);

  Serial.println(" ");
  Serial.println("Sensing the Water Level");

}

void loop()
{
  digitalWrite(TRIGGERPIN, LOW);
  delayMicroseconds(3);
  digitalWrite(TRIGGERPIN, HIGH);
  delayMicroseconds(12); // it may be 10 us
  digitalWrite(TRIGGERPIN, LOW);

// Reads the echoPin, returns the sound wave travel time in microseconds
  duration = pulseIn(ECHOPIN, HIGH);
// Calculating the distance
  distance = (duration/2) / 29.1;
  distance1=23-distance;
  percentage = (distance1*100)/22 ;
  if (distance1 <= 4)
    {
```

```
    digitalWrite(PUMP, HIGH);
   }
   else if (distance1 >= 21)
    {
     digitalWrite(PUMP, LOW);
    }
  Serial.println(" ");
  Serial.print("Free Level : ");
  Serial.print(distance);
  Serial.print(" cm. Water Level: ");
  Serial.print(distance1);
  Serial.print(" cm. ");
  Serial.print(" percentage = ");
  Serial.print(percentage);
  Serial.print(" %");

  delay(500);

  display.clearDisplay();
  display.setCursor(0,0);
  display.drawRoundRect(0, 0, 128, 64, 8, WHITE);
//  display.drawRoundRect(5, 5, 118, 54, 8, WHITE);

// Sets the color to black with a white background
  display.setTextColor(WHITE);
  display.setCursor(30,6);
  display.setTextSize(1);
  display.println("WATER LEVEL");
  display.drawLine(6,17,120,17, WHITE);
  display.setCursor(15,28);
  display.println("LEVEL = ");
  display.setTextSize(2);
  display.setCursor(65,25);
  display.println(distance1);
  display.setCursor(95,25);
  display.setTextSize(2);
  display.println("cm");

  display.drawLine(6,45,120,45, WHITE);
  display.setCursor(16,50);
  display.setTextSize(1);
  display.println("Monitor + Control");
  display.display();
}
```

Appendix C

(Data Sheets)

ESP8266EX

Datasheet

Version 6.9

Espressif Systems

1. Overview

Espressif's ESP8266EX delivers highly integrated Wi-Fi SoC solution to meet users' continuous demands for efficient power usage, compact design and reliable performance in the Internet of Things industry.

With the complete and self-contained Wi-Fi networking capabilities, ESP8266EX can perform either as a standalone application or as the slave to a host MCU. When ESP8266EX hosts the application, it promptly boots up from the flash. The integrated high-speed cache helps to increase the system performance and optimize the system memory. Also, ESP8266EX can be applied to any microcontroller design as a Wi-Fi adaptor through SPI/SDIO or UART interfaces.

ESP8266EX integrates antenna switches, RF balun, power amplifier, low noise receive amplifier, filters and power management modules. The compact design minimizes the PCB size and requires minimal external circuitries.

Besides the Wi-Fi functionalities, ESP8266EX also integrates an enhanced version of Tensilica's L106 Diamond series 32-bit processor and on-chip SRAM. It can be interfaced with external sensors and other devices through the GPIOs. Software Development Kit (SDK) provides sample codes for various applications.

Espressif Systems' Smart Connectivity Platform (ESCP) enables sophisticated features including:

- Fast switch between sleep and wakeup mode for energy-efficient purpose;
- Adaptive radio biasing for low-power operation
- Advance signal processing
- Spur cancellation and RF co-existence mechanisms for common cellular, Bluetooth, DDR, LVDS, LCD interference mitigation

1.1. Wi-Fi Key Features

- 802.11 b/g/n support
- 802.11 n support (2.4 GHz), up to 72.2 Mbps
- Defragmentation
- 2 x virtual Wi-Fi interface
- Automatic beacon monitoring (hardware TSF)
- Support Infrastructure BSS Station mode/SoftAP mode/Promiscuous mode

1.2. Specifications

Table 1-1. Specifications

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

📖 ***Note:***

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

1.3. Applications

- Home appliances
- Home automation
- Smart plugs and lights
- Industrial wireless control
- Baby monitors
- IP cameras
- Sensor networks
- Wearable electronics
- Wi-Fi location-aware devices
- Security ID tags
- Wi-Fi position system beacons

2. Pin Definitions

Figure 2-1 shows the pin layout for 32-pin QFN package.

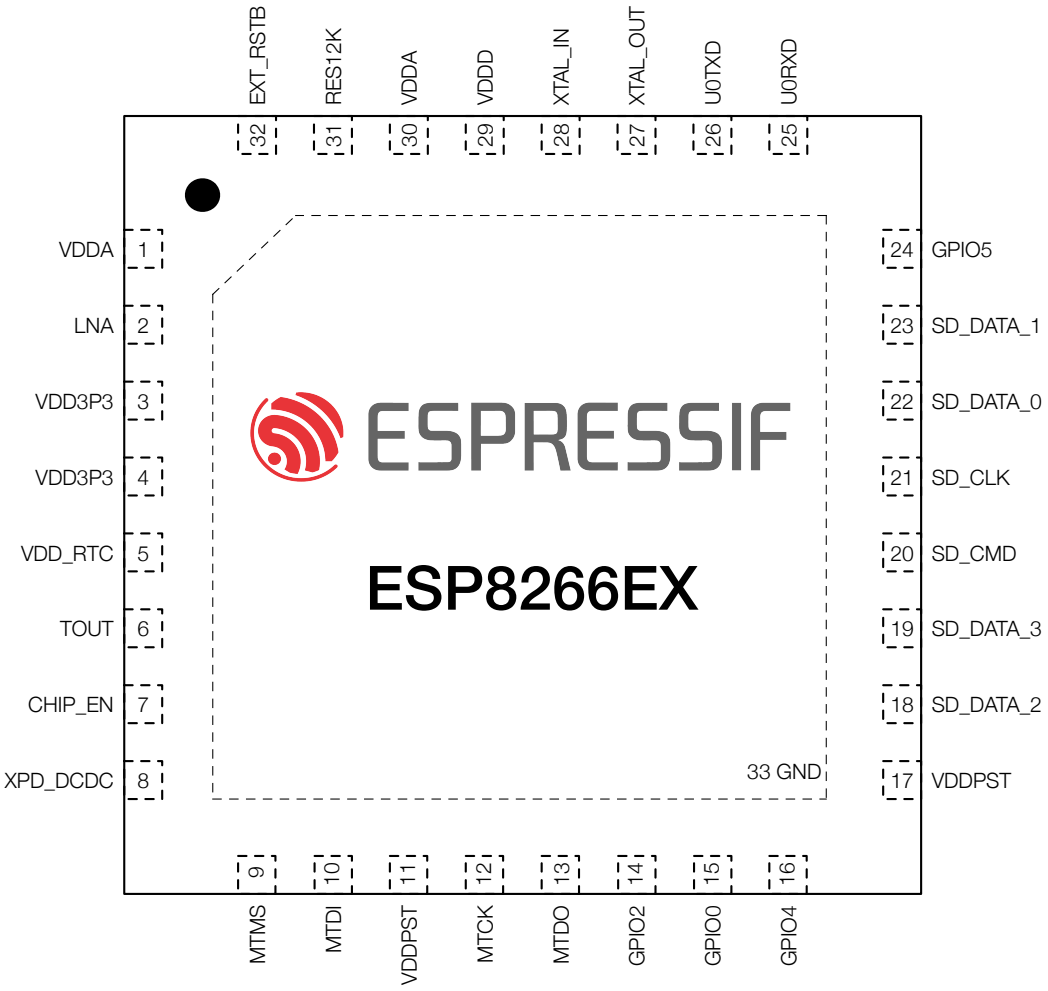


Figure 2-1. Pin Layout (Top View)

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

Table 2-1. ESP8266EX Pin Definitions

Pin	Name	Type	Function
1	VDDA	P	Analog Power 2.5 V ~ 3.6 V
2	LNA	I/O	RF antenna interface Chip output impedance = 39 + j6 Ω. It is suggested to retain the π-type matching network to match the antenna.
3	VDD3P3	P	Amplifier Power 2.5 V ~ 3.6 V

Pin	Name	Type	Function
4	VDD3P3	P	Amplifier Power 2.5 V ~ 3.6 V
5	VDD_RTC	P	NC (1.1 V)
6	TOUT	I	ADC pin. It can be used to test the power-supply voltage of VDD3P3 (Pin3 and Pin4) and the input power voltage of TOUT (Pin 6). However, these two functions cannot be used simultaneously.
7	CHIP_EN	I	Chip Enable High: On, chip works properly Low: Off, small current consumed
8	XPD_DCDC	I/O	Deep-sleep wakeup (need to be connected to EXT_RSTB); GPIO16
9	MTMS	I/O	GPIO 14; HSPI_CLK
10	MTDI	I/O	GPIO 12; HSPI_MISO
11	VDDPST	P	Digital/IO Power Supply (1.8 V ~ 3.6 V)
12	MTCK	I/O	GPIO 13; HSPI_MOSI; UART0_CTS
13	MTDO	I/O	GPIO 15; HSPI_CS; UART0_RTS
14	GPIO2	I/O	UART TX during flash programming; GPIO2
15	GPIO0	I/O	GPIO0; SPI_CS2
16	GPIO4	I/O	GPIO4
17	VDDPST	P	Digital/IO Power Supply (1.8 V ~ 3.6 V)
18	SDIO_DATA_2	I/O	Connect to SD_D2 (Series R: 20 Ω); SPIHD; HSPIHD; GPIO9
19	SDIO_DATA_3	I/O	Connect to SD_D3 (Series R: 200 Ω); SPIWP; HSPIWP; GPIO10
20	SDIO_CMD	I/O	Connect to SD_CMD (Series R: 200 Ω); SPI_CS0; GPIO11
21	SDIO_CLK	I/O	Connect to SD_CLK (Series R: 200 Ω); SPI_CLK; GPIO6
22	SDIO_DATA_0	I/O	Connect to SD_D0 (Series R: 200 Ω); SPI_MISO; GPIO7
23	SDIO_DATA_1	I/O	Connect to SD_D1 (Series R: 200 Ω); SPI_MOSI; GPIO8
24	GPIO5	I/O	GPIO5
25	U0RXD	I/O	UART Rx during flash programming; GPIO3
26	U0TXD	I/O	UART TX during flash programming; GPIO1; SPI_CS1
27	XTAL_OUT	I/O	Connect to crystal oscillator output, can be used to provide BT clock input
28	XTAL_IN	I/O	Connect to crystal oscillator input
29	VDDD	P	Analog Power 2.5 V ~ 3.6 V
30	VDDA	P	Analog Power 2.5 V ~ 3.6 V

Pin	Name	Type	Function
31	RES12K	I	Serial connection with a 12 kΩ resistor and connect to the ground
32	EXT_RSTB	I	External reset signal (Low voltage level: active)

📖 ***Note:***

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

3. Functional Description

The functional diagram of ESP8266EX is shown as in Figure 3-1.

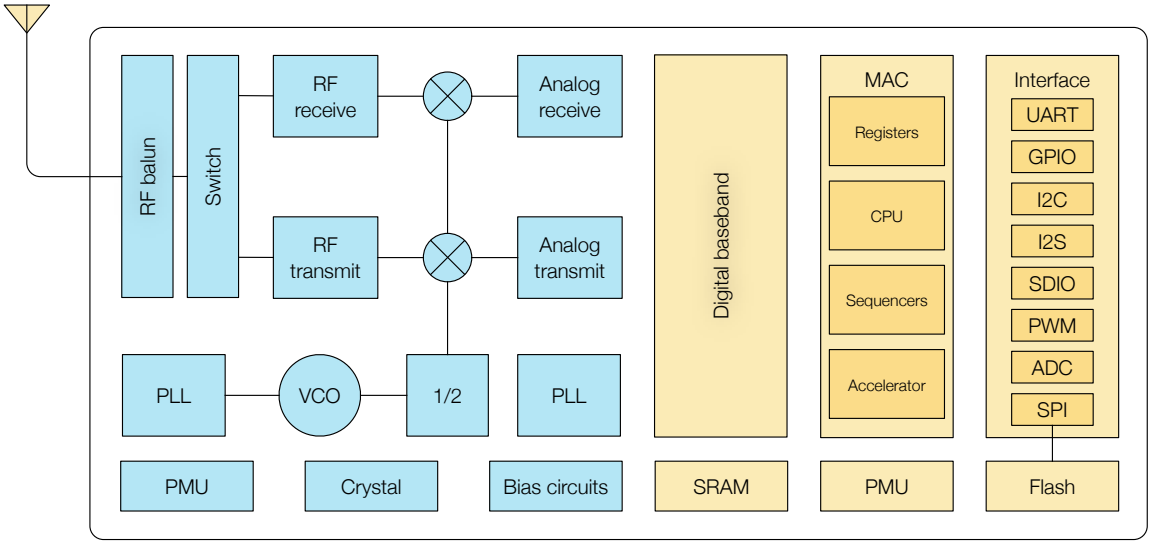


Figure 3-1. Functional Block Diagram

3.1. CPU, Memory, and Flash

3.1.1. CPU

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

- Programmable RAM/ROM interfaces (iBus), which can be connected with memory controller, and can also be used to visit flash.
- Data RAM interface (dBus), which can connected with memory controller.
- AHB interface which can be used to visit the register.

For information about the Xtensa® Instruction Set Architecture, please refer to *Xtensa® Instruction Set Architecture (ISA) Summary*.

3.1.2. Memory

ESP8266EX Wi-Fi SoC integrates memory controller and memory units including SRAM and ROM. MCU can access the memory units through iBus, dBus, and AHB interfaces. All memory units can be accessed upon request, while a memory arbiter will decide the

running sequence according to the time when these requests are received by the processor.

According to our current version of SDK, SRAM space available to users is assigned as below.

- RAM size < 50 kB, that is, when ESP8266EX is working under the Station mode and connects to the router, the maximum programmable space accessible in Heap + Data section is around 50 kB.
- There is no programmable ROM in the SoC. Therefore, user program must be stored in an external SPI flash.

3.1.3. External Flash

ESP8266EX uses external SPI flash to store user programs, and supports up to 16 MB memory capacity theoretically.

The minimum flash memory of ESP8266EX is shown below:

- OTA disabled: 512 kB at least
- OTA enabled: 1 MB at least

> ⚠ **Notice:**
>
> *SPI mode supported: Standard SPI, Dual SPI and Quad SPI. The correct SPI mode should be selected when flashing bin files to ESP8266. Otherwise, the downloaded firmware/program may not be working properly.*

3.2. Clock

3.2.1. High Frequency Clock

The high frequency clock on ESP8266EX is used to drive both transmit and receive mixers. This clock is generated from internal crystal oscillator and external crystal. The crystal frequency ranges from 24 MHz to 52 MHz.

The internal calibration inside the crystal oscillator ensures that a wide range of crystals can be used, nevertheless the quality of the crystal is still a factor to consider to have reasonable phase noise and good Wi-Fi sensitivity. Refer to Table 3-1 to measure the frequency offset.

Table 3-1. High Frequency Clock Specifications

Parameter	Symbol	Min	Max	Unit
Frequency	FXO	24	52	MHz
Loading capacitance	CL	-	32	pF
Motional capacitance	CM	2	5	pF

Parameter	Symbol	Min	Max	Unit
Series resistance	RS	0	65	Ω
Frequency tolerance	ΔFXO	–15	15	ppm
Frequency vs temperature (–25 °C ~ 75 °C)	ΔFXO,Temp	–15	15	ppm

3.2.2. External Clock Requirements

An externally generated clock is available with the frequency ranging from 24 MHz to 52 MHz. The following characteristics are expected to achieve good performance of radio.

Table 3-2. External Clock Reference

Parameter	Symbol	Min	Max	Unit
Clock amplitude	VXO	0.8	1.5	Vpp
External clock accuracy	ΔFXO,EXT	–15	15	ppm
Phase noise @1-kHz offset, 40-MHz clock	-	-	–120	dBc/Hz
Phase noise @10-kHz offset, 40-MHz clock	-	-	–130	dBc/Hz
Phase noise @100-kHz offset, 40-MHz clock	-	-	–138	dBc/Hz

3.3. Radio

ESP8266EX radio consists of the following blocks.

- 2.4 GHz receiver
- 2.4 GHz transmitter
- High speed clock generators and crystal oscillator
- Bias and regulators
- Power management

3.3.1. Channel Frequencies

The RF transceiver supports the following channels according to IEEE802.11 b/g/n standards.

Table 3-3. Frequency Channel

Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)
1	2412	8	2447
2	2417	9	2452
3	2422	10	2457

Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)
4	2427	11	2462
5	2432	12	2467
6	2437	13	2472
7	2442	14	2484

3.3.2. 2.4 GHz Receiver

The 2.4 GHz receiver down-converts the RF signals to quadrature baseband signals and converts them to the digital domain with 2 high resolution high speed ADCs. To adapt to varying signal channel conditions, RF filters, automatic gain control (AGC), DC offset cancelation circuits and baseband filters are integrated within ESP8266EX.

3.3.3. 2.4 GHz Transmitter

The 2.4 GHz transmitter up-converts the quadrature baseband signals to 2.4 GHz, and drives the antenna with a high-power CMOS power amplifier. The function of digital calibration further improves the linearity of the power amplifier, enabling a state of art performance of delivering +19.5 dBm average TX power for 802.11b transmission and +18 dBm for 802.11n (MSC0) transmission.

Additional calibrations are integrated to offset any imperfections of the radio, such as:

- Carrier leakage
- I/Q phase matching
- Baseband nonlinearities

These built-in calibration functions reduce the product test time and make the test equipment unnecessary.

3.3.4. Clock Generator

The clock generator generates quadrature 2.4 GHz clock signals for the receiver and transmitter. All components of the clock generator are integrated on the chip, including all inductors, varactors, loop filters, linear voltage regulators and dividers.

The clock generator has built-in calibration and self test circuits. Quadrature clock phases and phase noise are optimized on-chip with patented calibration algorithms to ensure the best performance of the receiver and transmitter.

3.4. Wi-Fi

ESP8266EX implements TCP/IP and full 802.11 b/g/n WLAN MAC protocol. It supports Basic Service Set (BSS) STA and SoftAP operations under the Distributed Control Function

(DCF). Power management is handled with minimum host interaction to minimize active-duty period.

3.4.1. Wi-Fi Radio and Baseband

The ESP8266EX Wi-Fi Radio and Baseband support the following features:

- 802.11 b and 802.11 g
- 802.11 n MCS0-7 in 20 MHz bandwidth
- 802.11 n 0.4 µs guard-interval
- up to 72.2 Mbps of data rate
- Receiving STBC 2 x 1
- Up to 20.5 dBm of transmitting power
- Adjustable transmitting power

3.4.2. Wi-Fi MAC

The ESP8266EX Wi-Fi MAC applies low-level protocol functions automatically, as follows:

- 2 × virtual Wi-Fi interfaces
- Infrastructure BSS Station mode/SoftAP mode/Promiscuous mode
- Request To Send (RTS), Clear To Send (CTS) and Immediate Block ACK
- Defragmentation
- CCMP (CBC-MAC, counter mode), TKIP (MIC, RC4), WEP (RC4) and CRC
- Automatic beacon monitoring (hardware TSF)
- Dual and single antenna Bluetooth co-existence support with optional simultaneous receive (Wi-Fi/Bluetooth) capability

3.5. Power Management

ESP8266EX is designed with advanced power management technologies and intended for mobile devices, wearable electronics and the Internet of Things applications.

The low-power architecture operates in the following modes:

- Active mode: The chip radio is powered on. The chip can receive, transmit, or listen.
- Modem-sleep mode: The CPU is operational. The Wi-Fi and radio are disabled.
- Light-sleep mode: The CPU and all peripherals are paused. Any wake-up events (MAC, host, RTC timer, or external interrupts) will wake up the chip.
- Deep-sleep mode: Only the RTC is operational and all other part of the chip are powered off.

Table 3-4. Power Consumption by Power Modes

Power Mode	Description	Power Consumption
Active (RF working)	Wi-Fi TX packet	Please refer to Table 5-2.
	Wi-Fi RX packet	
Modem-sleep①	CPU is working	15 mA
Light-sleep②	-	0.9 mA
Deep-sleep③	Only RTC is working	20 uA
Shut down	-	0.5 uA

📖 ***Notes:***

① ***Modem-sleep*** *mode is used in the applications that require the CPU to be working, as in PWM or I2S applications. According to 802.11 standards (like U-APSD), it shuts down the Wi-Fi Modem circuit while maintaining a Wi-Fi connection with no data transmission to optimize power consumption. E.g., in DTIM3, maintaining a sleep of 300 ms with a wakeup of 3 ms cycle to receive AP's Beacon packages at interval requires about 15 mA current.*

② *During* ***Light-sleep*** *mode, the CPU may be suspended in applications like Wi-Fi switch. Without data transmission, the Wi-Fi Modem circuit can be turned off and CPU suspended to save power consumption according to the 802.11 standards (U-APSD). E.g. in DTIM3, maintaining a sleep of 300 ms with a wakeup of 3ms to receive AP's Beacon packages at interval requires about 0.9 mA current.*

③ *During* ***Deep-sleep*** *mode, Wi-Fi is turned off. For applications with long time lags between data transmission, e.g. a temperature sensor that detects the temperature every 100 s, sleeps for 300 s and wakes up to connect to the AP (taking about 0.3 ~ 1 s), the overall average current is less than 1 mA. The current of 20 μA is acquired at the voltage of 2.5 V.*

4. Peripheral Interface

4.1. General Purpose Input/Output Interface (GPIO)

ESP8266EX has 17 GPIO pins which can be assigned to various functions by programming the appropriate registers.

Each GPIO PAD can be configured with internal pull-up or pull-down (XPD_DCDC can only be configured with internal pull-down, other GPIO PAD can only be configured with internal pull-up), or set to high impedance. When configured as an input, the data are stored in software registers; the input can also be set to edge-trigger or level trigger CPU interrupts. In short, the IO pads are bi-directional, non-inverting and tristate, which includes input and output buffer with tristate control inputs.

These pins, when working as GPIOs, can be multiplexed with other functions such as I2C, I2S, UART, PWM, and IR Remote Control, etc.

4.2. Secure Digital Input/Output Interface (SDIO)

ESP8266EX has one Slave SDIO, the definitions of which are described as Table 4-1, which supports 25 MHz SDIO v1.1 and 50 MHz SDIO v2.0, and 1 bit/4 bit SD mode and SPI mode.

Table 4-1. Pin Definitions of SDIOs

Pin Name	Pin Num	IO	Function Name
SDIO_CLK	21	IO6	SDIO_CLK
SDIO_DATA0	22	IO7	SDIO_DATA0
SDIO_DATA1	23	IO8	SDIO_DATA1
SDIO_DATA_2	18	IO9	SDIO_DATA_2
SDIO_DATA_3	19	IO10	SDIO_DATA_3
SDIO_CMD	20	IO11	SDIO_CMD

4.3. Serial Peripheral Interface (SPI/HSPI)

ESP8266EX has two SPIs.

- One general Slave/Master SPI
- One general Slave/Master HSPI

Functions of all these pins can be implemented via hardware.

4.3.1. General SPI (Master/Slave)

Table 4-2. Pin Definitions of SPIs

Pin Name	Pin Num	IO	Function Name
SDIO_CLK	21	IO6	SPICLK
SDIO_DATA0	22	IO7	SPIQ/MISO
SDIO_DATA1	23	IO8	SPID/MOSI
SDIO_DATA_2	18	IO9	SPIHD
SDIO_DATA_3	19	IO10	SPIWP
U0TXD	26	IO1	SPICS1
GPIO0	15	IO0	SPICS2
SDIO_CMD	20	IO11	SPICS0

📖 ***Note:***

SPI mode can be implemented via software programming. The clock frequency is 80 MHz at maximum when working as a master, 20 MHz at maximum when working as a slave.

4.3.2. HSPI (Master/Slave)

Table 4-3. Pin Definitions of HSPI

Pin Name	Pin Num	IO	Function Name
MTMS	9	IO14	HSPICLK
MTDI	10	IO12	HSPIQ/MISO
MTCK	12	IO13	HSPID/MOSI
MTDO	13	IO15	HPSICS

📖 ***Note:***

SPI mode can be implemented via software programming. The clock frequency is 20 MHz at maximum.

4.4. I2C Interface

ESP8266EX has one I2C, which is realized via software programming, used to connect with other microcontrollers and other peripheral equipments such as sensors. The pin definition of I2C is as below.

Table 4-4. Pin Definitions of I2C

Pin Name	Pin Num	IO	Function Name
MTMS	9	IO14	I2C_SCL
GPIO2	14	IO2	I2C_SDA

Both I2C Master and I2C Slave are supported. I2C interface functionality can be realized via software programming, and the clock frequency is 100 kHz at maximum.

4.5. I2S Interface

ESP8266EX has one I2S data input interface and one I2S data output interface, and supports the linked list DMA. I2S interfaces are mainly used in applications such as data collection, processing, and transmission of audio data, as well as the input and output of serial data. For example, LED lights (WS2812 series) are supported. The pin definition of I2S is shown in Table 4-5.

Table 4-5. Pin Definitions of I2S

I2S Data Input			
Pin Name	Pin Num	IO	Function Name
MTDI	10	IO12	I2SI_DATA
MTCK	12	IO13	I2SI_BCK
MTMS	9	IO14	I2SI_WS
MTDO	13	IO15	I2SO_BCK
U0RXD	25	IO3	I2SO_DATA
GPIO2	14	IO2	I2SO_WS

4.6. Universal Asynchronous Receiver Transmitter (UART)

ESP8266EX has two UART interfaces UART0 and UART1, the definitions are shown in Table 4-6.

Table 4-6. Pin Definitions of UART

Pin Type	Pin Name	Pin Num	IO	Function Name
UART0	U0RXD	25	IO3	U0RXD
	U0TXD	26	IO1	U0TXD
	MTDO	13	IO15	U0RTS
	MTCK	12	IO13	U0CTS
UART1	GPIO2	14	IO2	U1TXD
	SD_D1	23	IO8	U1RXD

Data transfers to/from UART interfaces can be implemented via hardware. The data transmission speed via UART interfaces reaches 115200 x 40 (4.5 Mbps).

UART0 can be used for communication. It supports flow control. Since UART1 features only data transmit signal (TX), it is usually used for printing log.

> 📖 ***Note:***
>
> *By default, UART0 outputs some printed information when the device is powered on and booting up. The baud rate of the printed information is relevant to the frequency of the external crystal oscillator. If the frequency of the crystal oscillator is 40 MHz, then the baud rate for printing is 115200; if the frequency of the crystal oscillator is 26 MHz, then the baud rate for printing is 74880. If the printed information exerts any influence on the functionality of the device, it is suggested to block the printing during the power-on period by changing (U0TXD, U0RXD) to (MTDO, MTCK).*

4.7. Pulse-Width Modulation (PWM)

ESP8266EX has four PWM output interfaces. They can be extended by users themselves. The pin definitions of the PWM interfaces are defined as below.

Table 4-7. Pin Definitions of PWM

Pin Name	Pin Num	IO	Function Name
MTDI	10	IO12	PWM0
MTDO	13	IO15	PWM1
MTMS	9	IO14	PWM2
GPIO4	16	IO4	PWM3

The functionality of PWM interfaces can be implemented via software programming. For example, in the LED smart light demo, the function of PWM is realized by interruption of the timer, the minimum resolution reaches as high as 44 ns. PWM frequency range is adjustable from 1000 µs to 10000 µs, i.e., between 100 Hz and 1 kHz. When the PWM

frequency is 1 kHz, the duty ratio will be 1/22727, and a resolution of over 14 bits will be achieved at 1 kHz refresh rate.

4.8. IR Remote Control

ESP8266EX currently supports one infrared remote control interface. For detailed pin definitions, please see Table 4-8 below.

Table 4-8. Pin Definitions of IR Remote Control

Pin Name	Pin Num	IO	Function Name
MTMS	9	IO14	IR TX
GPIO5	24	IO 5	IR Rx

The functionality of Infrared remote control interface can be implemented via software programming. NEC coding, modulation, and demodulation are supported by this interface. The frequency of modulated carrier signal is 38 kHz, while the duty ratio of the square wave is 1/3. The transmission range is around 1m which is determined by two factors: one is the maximum current drive output, the other is internal current-limiting resistance value in the infrared receiver. The larger the resistance value, the lower the current, so is the power, and vice versa.

4.9. ADC (Analog-to-Digital Converter)

ESP8266EX is embedded with a 10-bit precision SAR ADC. TOUT (Pin6) is defined as below:

Table 4-9. Pin Definition of ADC

Pin Name	Pin Num	Function Name
TOUT	6	ADC Interface

The following two measurements can be implemented using ADC (Pin6). However, they cannot be implemented at the same time.

- Measure the power supply voltage of VDD3P3 (Pin3 and Pin4).

Hardware Design	TOUT must be floating.
RF Initialization Parameter	The 107th byte of ***esp_init_data_default.bin*** (0 ~ 127 bytes), `vdd33_const` must be set to `0xFF`.
RF Calibration Process	Optimize the RF circuit conditions based on the testing results of VDD3P3 (Pin3 and Pin4).
User Programming	Use `system_get_vdd33` instead of `system_adc_read`.

- Measure the input voltage of TOUT (Pin6).

Hardware Design	The input voltage range is 0 to 1.0 V when TOUT is connected to external circuit.
RF Initialization Parameter	The value of the 107th byte of ***esp_init_data_default.bin*** (0 ~ 127 bytes), `vdd33_const` must be set to the real power supply voltage of Pin3 and Pin4. The unit and effective value range of `vdd33_const` is 0.1 V and 18 to 36, respectively, thus making the working power voltage range of ESP8266EX between 1.8 V and 3.6 V.
RF Calibration Process	Optimize the RF circuit conditions based on the value of `vdd33_const`. The permissible error is ± 0.2 V.
User Programming	Use `system_adc_read` instead of `system_get_vdd33`.

📖 ***Notes:***

esp_init_data_default.bin *is provided in SDK package which contains RF initialization parameters (0 ~ 127 bytes). The name of the 107th byte in* ***esp_init_data_default.bin*** *is* `vdd33_const`*, which is defined as below:*

- *When vdd33_const = 0xff, the power voltage of Pin3 and Pin4 will be tested by the internal self-calibration process of ESP8266EX itself. RF circuit conditions should be optimized according to the testing results.*
- *When 18 = < vdd33_const = < 36, ESP8266EX RF Calibration and optimization process is implemented via (vdd33_const/10).*
- *When vdd33_const < 18 or 36 < vdd33_const < 255, vdd33_const is invalid. ESP8266EX RF Calibration and optimization process is implemented via the default value 3.3 V.*

- Operating temperature range: -40^{0}C - +80^{0}C
- Use I2C Interface
- Chip No: SSD1306
- Color: Blue
- Drive Duty: 1/64 Duty
- Only need 2 I/O port to control
- Supported platforms: For Arduino,51 series, MSP430 series, STIM32/2, SCR chips
- Super high contrast and brightness(adjustable)
- Low power consumption
- High contrast, thus supporting clear display with no need of backlight
- For OLED SSD1306, a more elaborate and beautiful screen than LCD with more functions

PIN DESCRIPTION:

Pin No.	Pin Name	Description
1.	Supply Voltage (Vcc, 5V)	Can be powered by either 3.3V or 5V
2.	Ground (GND)	Pin Ground
3.	Serial Clock(SCL)	Pin SCL of I2C interface
4.	Serial Data(SDA)	Pin SDA of I2C interface

MECHANICAL SPECIFICATIONS:

ITEM	NORMAL DIMENSION
Module Dimension	27.30*27.30*2.37
Active Area	21.74*10.86
Pixel Size	0.148*0.148
Pixel Pitch	0.17*0.17

ABSOLUTE MAXIMUM RATING:

PARAMETER	SYMBOL	MIN	MAX	UNIT
Supply voltage for logic	VCC	1.65	5.5	V
Operating temperature	TOP	-40	+80	ºC
Storage temperature	TSTG	-40	+80	ºC

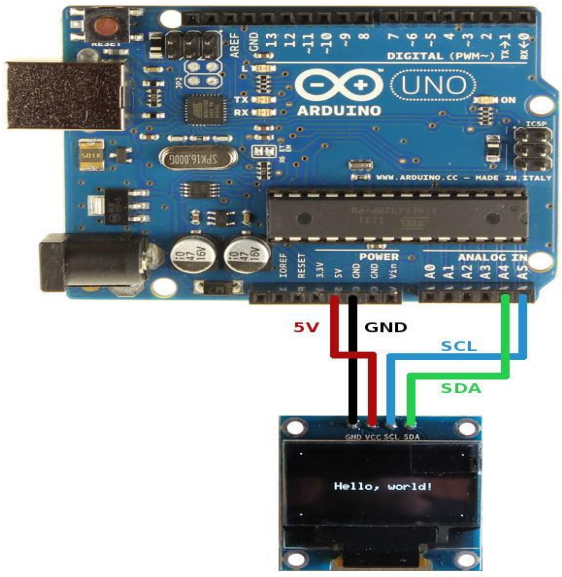
ELECTRONICAL CHARACTERISTICS:

ITEM	SYMBOL	CONDITION	MIN	TYP	MAX	UNIT
Supply voltage for logic	VCC	------	2.8	3.3	5.2	V
Input high voltage	VIH	------	0.8*VCC	-----	VCC	V
Input low voltage	VIL	------	0	-----	0.2*VCC	V
Output high voltage	VOH	------	0.9*VCC	-----	VCC	V
Output low voltage	VOL	------	0	-----	0.1*VCC	V
50%check board operating current	ICC	VCC=3.3	------	12.0	20.0	mA

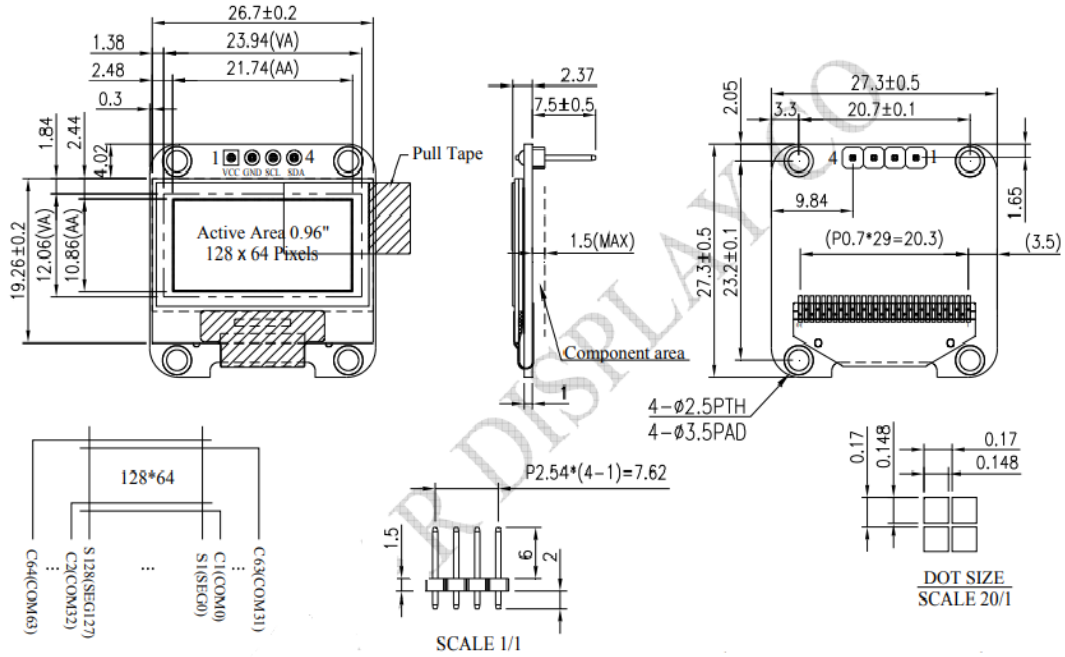
CONNECTION DIAGRAM OF ARDUINO UNO TO 4 PIN 0.96 INCH I2C OLED DISPLAY TO ARDUINO UNO:

Arduino Uno OLED Wiring
The image below shows how to connect the 0.96inch OLED I2C display to Arduino. Pin connections are as follows for wiring the OLED display to an Arduino Uno.

- OLED GND – Arduino GND
- OLED VCC – Arduino 5V
- OLED SCL – Arduino Uno A5
- OLED SDA – Arduino Uno A4



OUTER DIMENSION:



APPLICATIONS:

Due to its capability in displaying, it is often used in various application for instances, smart watch, MP3, function cellphone, portable health device and many others.