

AQUAPONICS MONITORING AND CONTROLLING USING IOT

Submitted in partial fulfilment of the requirements for the award of

**Bachelor of Engineering degree in
Electronics and Communication Engineering**

By

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NAKOTI KALYAN (38130147)



**SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING
DEPARTMENT OF ELECTRONICS AND COMMUNICATION
ENGINEERING**

**SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade “A” by NAAC JEPPIAAR NAGAR,
RAJIV GANDHI SALAI, CHENNAI - 600 119**

March - 2022



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of

Potini Jayanth Sai Chowdary (38130169)

Nakoti Kalyan (38130147)

who carried out the project entitled **Aquaponics Controlling and Monitoring Using IoT** under my / our supervision from December 2021 to March 2022

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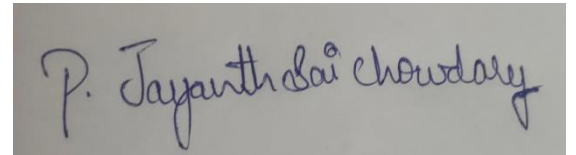
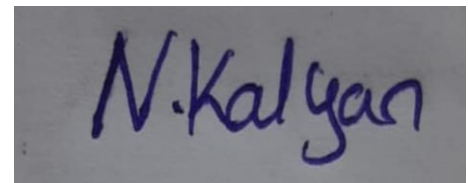
Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

We Mr. Potini Jayanth Sai Chowdary (38130169) and Mr. Nakoti Kalyan (38130147) hereby declare that the Project Report entitled **Aquaponics Controlling and Monitoring Using IoT** done by me under the guidance of **Dr. N.M. Nandhitha, M.E., Ph.D.,** is submitted in partial fulfilment of the requirements for the award of Bachelors of Engineering degree in Electronics and communications.

A rectangular box containing a handwritten signature in blue ink that reads "P. Jayanth Sai Chowdary".A rectangular box containing a handwritten signature in blue ink that reads "N. Kalyan".

DATE:11-03-2022

PLACE: Chennai

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to Board of Management of **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

I convey my thanks to **Dr. N.M. Nandhitha, Dean, School of Electrical and Electronics Engineering** and **Dr. T. Ravi, Head of the Department, Dept. of Electronics and Communication Engineering** for providing me necessary support and details at the right time during the progressive reviews.

I would like to express my sincere and deep sense of gratitude to my Project Guide **Dr. N.M. Nandhitha** for her valuable guidance, suggestions and constant encouragement paved way for the successful completion of my project work.

I wish to express my thanks to all Teaching and Non-teaching staff members of the Department of Department of Electronics and Communication Engineering who were helpful in many ways for the completion of the project.

ABSTRACT

Food security has been a recurring issue for many countries in the world including Singapore. This project further exploits the design and development of an aquaponics for a home environment, with the notion that if every household within a country can generate its fish and plants, the overall food demand of the country will be reduced. The proposed smart and sustainable home aquaponics system consists of various sensors, actuators, and microcontrollers with internet connectivity to continuously monitor, control, and record fish tank water and ambient air quality. Healthy growth of fish and plants is ensured by sending an early warning to the user in the event of any abnormal system condition via push notification in a feature-rich internet of things (IoT) mobile application. Furthermore, appropriate actuators are automatically operated to rectify abnormalities promptly. Plant grow lights and fish feeders are also automatically controlled to optimize fish and plant growth. Measurement results successfully demonstrate the efficacy of the proposed home aquaponics system to grow healthy fish and plants, with minimal operational costs and human intervention.

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CHAPTER 1

INTRODUCTION

1.1 AQUAPONICS MONITORING AND CONTROLLING USING IOT

Our population is growing day by day, with about 7.5 billion in the world by April 2017, and 103.3 million in the Philippines alone. According to the Food and Agriculture Organization of the United Nations, there would be an increase of another 2 billion people on the planet by the year 2050, and a 28% increase of food production would be needed to sustain the needs of the people in terms of Food supply. Another challenge is to maintain the cost, the safety, and the nutrition factor of food in such a way that it would still be accessible and affordable for everyone. In addition to this, as the population increases, the need for urbanization and industrialization arises as well. Countries tend to convert farming lands to residential areas, commercial areas, and industrial areas. For example, in the Philippines, a developing country, land conversions due to urbanization and industrialization decreases the available farming spaces in the Country. Moreover, from 1988 to 2016, 97592.5 hectares of agricultural land was converted for non-agricultural purposes, such as manufacturing facilities, high-rise buildings, highways, malls, hotels, and other commercial, residential, or industrial structures. This amount of land is equal to the land mass of Metro Manila and Cebu combined, two of the biggest cities in the Philippines, Metro Manila being the capital. With the growing population, urban farming has been gaining attention in the recent years because of its accessibility and efficient use of space, which address rapid growth of the urban population. It is defined as the process of cultivating food (e.g. crops and livestock) in urban areas. According to Tornaghi, urban agriculture in contrast to rural farming has the following

attributes: higher productivity per unit of space, low energy consumption, and low capital per unit of production.

The proposed aquaponics system by the researchers aims to provide an accessible, low-maintenance, and sustainable source of food for condominium residents as an alternative to market goods. A good number of condominium buildings have been built for the past few years in Metro Manila because of the growing urban population. Studio type condominium units less than 50 square meters are being sold in Metro Manila. With this, the arable space and soil are some of the issues being addressed by the proposed soil-less farming system having overall dimensions of 43cm by 60 cm by 80 cm. The system is fully-automated requiring minimal time and effort from the owner, considering that most urban residents have busy schedules. Moreover, the proposed system offers a modular design such that individual aquaponics system is stackable and can be placed on top of the other providing increased productivity without occupying much space. This will also allow the user to grow a variety of plants or fish by having multiple aquaponics units. Also, data during plant and fish cultivation are saved and accessed through a web-based data logging system. Furthermore, plant growth is analysed through image processing and data analysis from the collected information that would enable future experimentation and comparisons.

CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE SURVEY

LABORATORY AQUAPONICS SYSTEM VIA PLC AND LABVIEW

In this project, a laboratory aquaponics system, which is developed to teach undergraduate students at Dalian Ocean University, Liaoning, China, some of the issues regarding aquaponics based on PLC and LabVIEW, is discussed. In this aquaponics system, to maintain the ecological balance of the water body, Siemens S7-1500 PLC is used to realize data acquisition and automatic control of various sensors and execution devices. LabVIEW programming is used to develop a friendly human-machine interface to realize data display, storage, query, and analysis. Finally, the real-time data exchange is completed through OPC communication technology, and the monitoring of the aquaponics system is realized. Experience in using this system in undergraduate teaching indicates that it supports learning of PLC and LabVIEW-related courses and it also in line with the marine fisheries characteristics of our school.

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DESIGN & IMPLEMENTATION OF INDOOR FARMING USING AUTOMATED AQUAPONICS SYSTEM

Aquaponics refers to the integration of hydroponics with aquaculture. It is the system of aquaculture in which the waste given out by the fish acts as the nutrition for plants grown hydroponically, this purifies the water in turn. It is an ecosystem where in plants and fish lives in a symbiotic relationship. The growth performance of comet goldfish against a plant of coriander, types of leafy vegetable and water plant were evaluated in recirculation of this aquaponics system towards temperature, light and fish waste effectively. The fish were feed with commercial pelleted feeds containing 30% crude protein which can provide almost all nutrients required for the plant growth. Auto feeder place major role in this system used to maintain the growth and survival rates. Filter systems used to remove the amount of waste materials and breakdown products from the water. The set point will be the desired water level, the monitored temperature in fish tank, the monitored temperature at plant area and the desired amount of food. While Arduino function as a brain that used to receive the information from the sensor and come out with an instruction in term of response as the feedback. Then the action will be based on the actuator that was reacted towards the act received.

EQUIPMENT AND INTELLIGENT CONTROL SYSTEM IN AQUAPONICS

Traditional planting and aquaculture has the problem of large consumption of water resources and land resources, and the water environmental pollution is also a difficult problem facing human beings. Population growth and food safety issues have promoted the concept of aquaponics—a recycling ecological planting and breeding mode. Aquaponics is a new technology in modern

agricultural production that combines aquaculture with hydroponics. Thus, vegetable planting no longer requires fertilization, and fish cultures do not need water changes as frequently. This change allows fish, cultivated crops and microorganisms to form mutually beneficial symbiosis and harmonious coexistence of ecological balance relationships. It combines hydroponics and recirculating aquaculture technology to realize water resources and nutrient recycling, low pollution and high productivity and efficiency. In this paper, hydroponics as the main vegetable cultivation method in aquaponics and the main equipment of water treatment in recirculating aquaculture are introduced, and the traditional equipment and its development prospects are analysed greenhouse environments, water quality and nutrient circulation involved in intelligent monitoring and control of aquaponic systems are systematically analysed and summarized. This paper summarizes the current development of technology and methods in aquaponics and provides prospects for future development trends. With the development of technology, in the future, the aquaponics system will become more intelligent, intensive, accurate and efficient

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CHAPTER 3

PROPOSED METHODOLOGY

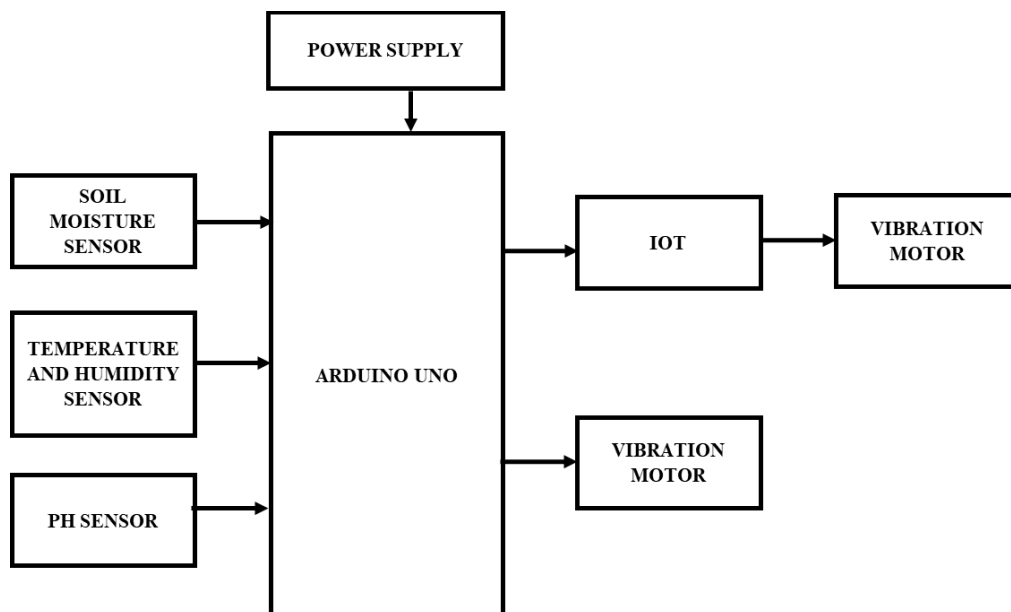
3.1 EXISTING SYSTEM:

- The Existing system also observes the air and water temperature, humidity, pH, and water level.
- Data gathered from the parameters only monitored by the Arduino microcontroller, it's not securely stored and doesn't use for further real-time analysis.

3.2 PROPOSED SYSTEM:

- In the proposed system, the sensor readings are monitored and displayed to the user in real-time through the IoT and securely sent to an online spreadsheet for storage and further analysis.
- We are proposing controlling the devices from anywhere by using the cloud.

3.3 BLOCK DIAGRAM:



3.4 HARDWARE REQUIREMENTS:

- ARDUINO UNO
- TEMPERATURE SENSOR
- HUMIDITY SENSOR
- SOIL MOISTURE SENSOR
- PH SENSOR
- ESP8266
- VIBRATION MOTOR

3.5 SOFTWARE REQUIREMENTS:

- ARDUINO IDE
- EMBEDDED C
- PHP
- LSTM

CHAPTER-4

HARDWARE COMPONENTS DETAILS

4.1 ARDUINO UNO:

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 Analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to the ground, making it easier to put into DFU mode. Revision 3 of the board has the following new features:

- 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In the future, shields will be compatible both with the board that uses the AVR, which operate with 5V, and with the Arduino Due which operates with 3.3V. The second one is a not-connected pin that is reserved for future purposes.
- Stronger RESET circuit.
- At mega 16U2 replace the 8U2. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

POWER:

VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

- 5V. This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

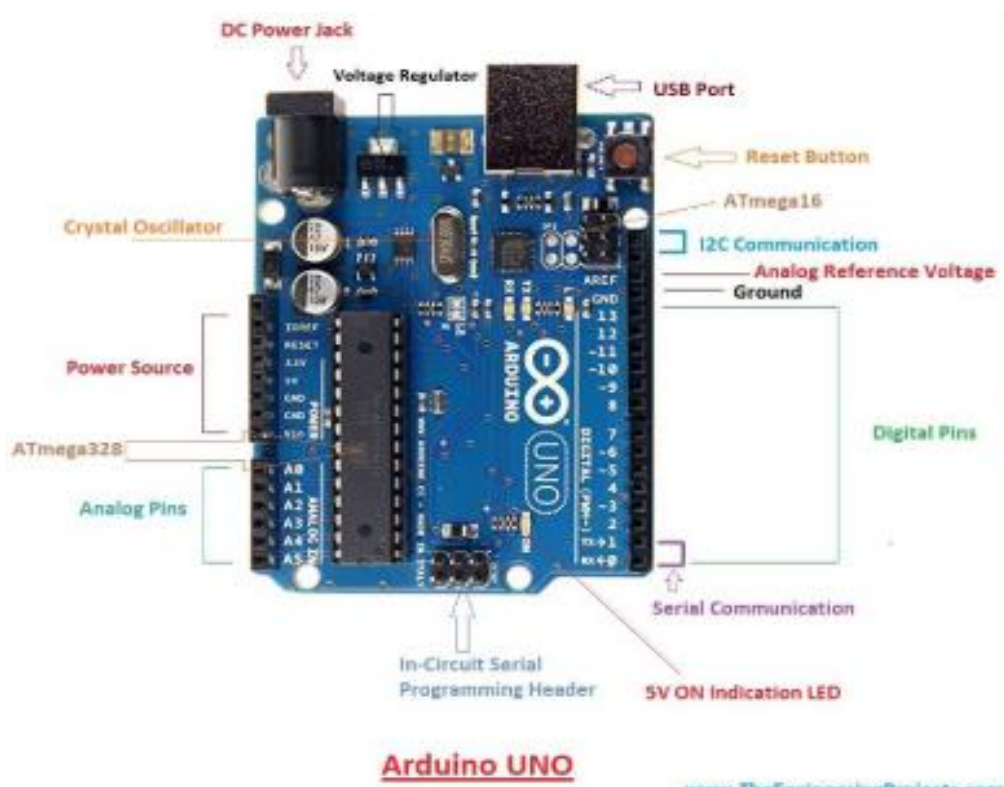


Fig 4.1 Arduino Uno diagram

- 3V 3. A 3.3-volt supply is generated by the onboard regulator. The maximum current draw is 50 mA.

- GND. Ground pins.

MEMORY:

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library). Input and Output each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode (), digital Write (), and digital Read () function. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 Kilo ohms.

In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attached Interrupt () function for details.
- PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog Write () function.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off. The Uno has 6 analog inputs, labeled A0 through A5, each of which provides 10 bits of resolution (i.e. 1024 different values). By default, they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the

analog Reference () function. Additionally, some pins have specialized functionality:

- TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library. There are a couple of other pins on the board:
- AREF. Reference voltage for the analog inputs. Used with analog Reference ().
- Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board. See also the mapping between Arduino pins and ATmega328 ports. The mapping for the Atmega8, 168, and 328 is identical. Communication the Arduino Uno has several facilities for communicating with a computer, another Arduino, or other microcontrollers.

The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed.

However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify the use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library.

PIN CONFIGURATION:

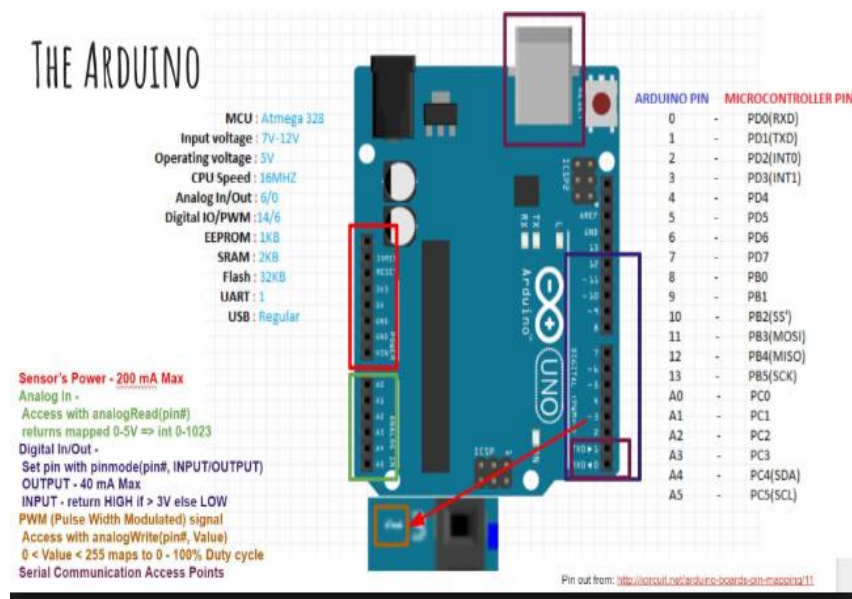


Fig 4.2 Pin diagram of Arduino Uno

USB Overcurrent Protection:

The Arduino Uno has a resettable poly fuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics:

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100-mil spacing of the other pins.

4.2 TEMPERATURE SENSOR:

‘The world is getting warmer day by day.’ This sentence has started to crop up now and then in our day-to-day lives. But seldom do we wonder what it means.

What is warmer? How warm is warm? Is it hotter than hot, or just hotter than cold? To our human senses, the temperature is only a subjective evaluation. For an objective and reproducible measurement, we need to quantify the temperature values, and to do that, a suitable measurement device is required

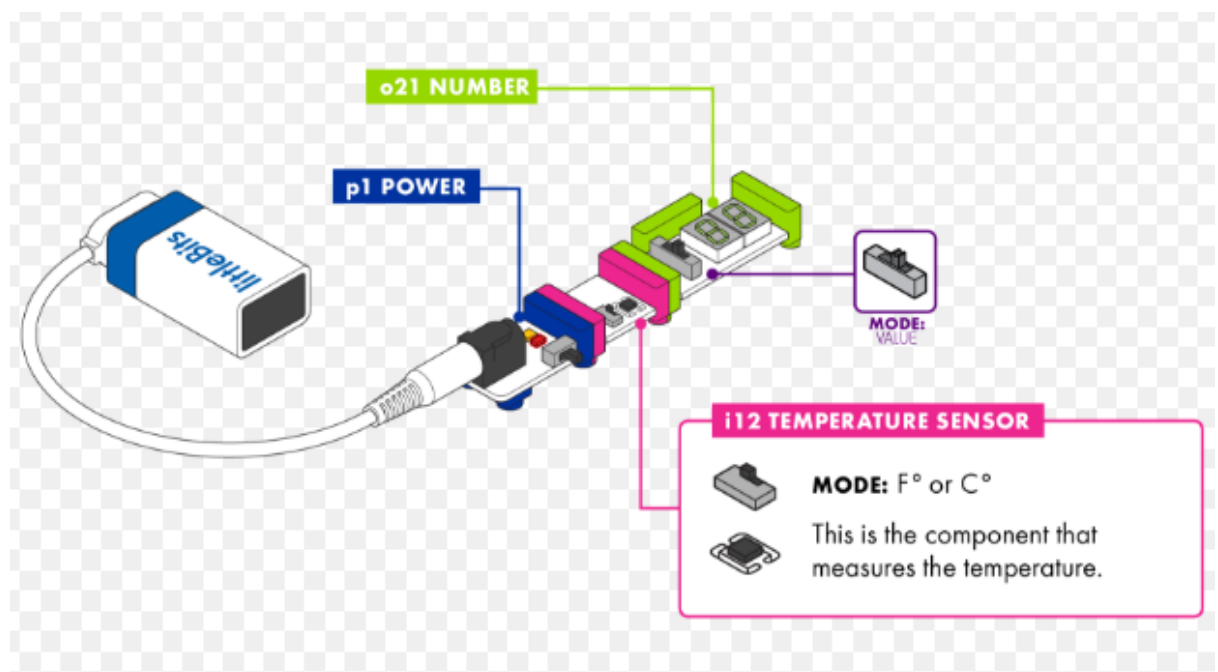
SPECIFICATIONS

Range	0°...100°C
Accuracy	< 0,1°C + NTC-spread over 0°...70°C
Resolution	2 m°C@30°C and 25 m°C@100°C
Linearity	see table
No. Sensors	1....30
Type	5 kOhm NTC-resistors Max. wireresistance 3,3 Ohm
Conditioner	Wheatstone-bridge with +15 Bits ADC
Calibration	at 0°C and 100°C _ 0,1°C
Drift	1 m°C/°C with periodic calibration and 5 m°C/°C without calibration
Scanfreq.	default max. 10 meas./s
Amb.temp	0°...60°
Control	Micro-Wire™ 5 (Di, Do, Clk en CS)
Levels	0 and 5 Volt
Power	+12 Volt 3,5 mAmp (+5,5 +20 Volt) -5 Volt 1 mAmp (-4,5 -8 Volt)
Dimensions	224 x 120 x 60 + 40 mm

Temperature and its Measurement

Simply speaking, the temperature is the degree of hotness of the body which is a measure of the heat content in the body. The problem to quantify the heat content of the body on a scale did not arise until the invention of the Steam Engine. The curiosity of scientists to understand the behavior of water at different levels of heat contents gave rise to a formal and better laid out study. One of the first references for ‘temperature’ dates back to 1760 when Joseph Black declared that applying the same heat to different materials resulted in different temperatures. Years of rigorous scientific study led to many theories ranging from

the simple ‘Caloric’ concept, which treated heat as a material substance which is exchanged among materials, to Carnot’s description of heat as a form of energy (which laid the foundation of the first law of thermodynamics). However, none of them satisfactorily explained the concept of temperature. It was Maxwell’s theory which offered good reasoning into it. He defined the temperature of a body as is its thermal property which provides information about the energy content of the system. It is the measure of the average kinetic energy (energy by motion) of the molecules of the substance and signifies a heat potential due to which heat flows from higher temperature to lower temperature.



There are many different types of Temperature Sensors available and all have different characteristics depending upon their actual application. A temperature sensor consists of two basic physical types:

- Contact Temperature Sensor Types – These types of temperature sensors are required to be in physical contact with the object being sensed and use conduction to monitor temperature changes. They can be used to detect solids, liquids, or gases over a wide range of temperatures.

- Non-contact Temperature Sensor Types – These types of temperature sensors use convection and radiation to monitor temperature changes. They can be used to detect liquids and gases that emit radiant energy as heat rises and cold settles to the bottom in convection currents or detect the radiant energy being transmitted from an object in the form of infra-red radiation (the sun).

The two basic types of contact or even non-contact temperature sensors can also be sub-divided into the following three groups of

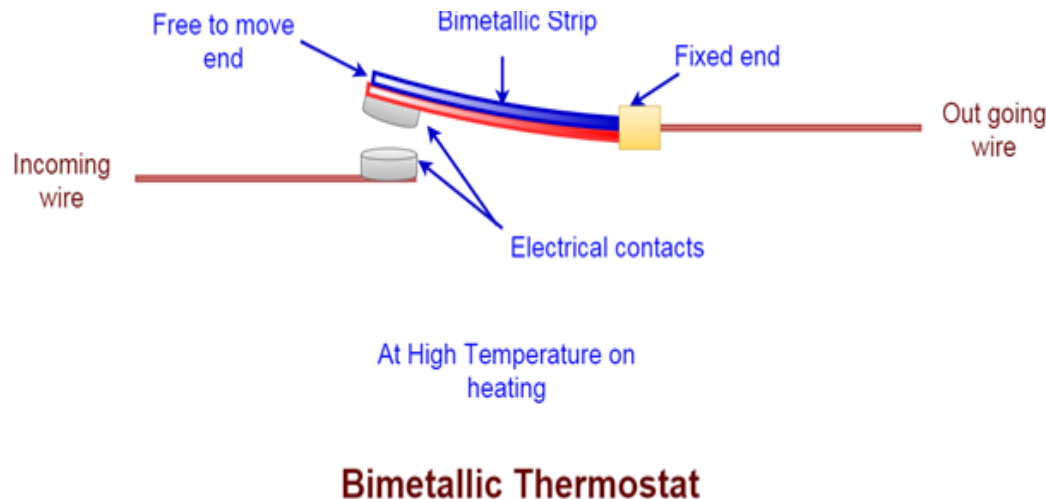
- sensors,
- Electro-mechanical,
- Resistive and Electronic.

The Thermostat

The Thermostat is a contact type electro-mechanical temperature sensor or switch, that consists of two different metals such as nickel, copper, tungsten, or aluminum, etc, that are bonded together to form a Bi-metallic strip. The different linear expansion rates of the two dissimilar metals produce a mechanical bending movement when the strip is subjected to heat.

The bimetallic strip can be used as an electrical switch or as a mechanical way of operating an electrical switch in thermostatic controls and is used extensively to control hot water heating elements in boilers, furnaces, hot water storage tanks as well as in-vehicle radiator cooling systems.

The Bi-metallic Thermostat



The thermostat consists of two thermally different metals stuck together back to back. When it is cold the contacts are closed and current passes through the thermostat. When it gets hot, one metal expands more than the other and the bonded bi-metallic strip bends up (or down) opening the contacts preventing the current from flowing.

On/Off Thermostat

There are two main types of bi-metallic strips based mainly upon their movement when subjected to temperature changes. There are the “snap-action” types that produce an instantaneous “ON/OFF” or “OFF/ON” type action on the electrical contacts at a set temperature point, and the slower “creep-action” types that gradually change their position as the temperature changes.

Snap-action type thermostats are commonly used in our homes for controlling the temperature set point of ovens, irons, immersion hot water tanks and they can also be found on walls to control the domestic heating system.

Creeper types generally consist of a bi-metallic coil or spiral that slowly unwinds or coils up as the temperature changes. Generally, creeper type bi-metallic strips are more sensitive to temperature changes than the standard snap ON/OFF types as the strip is longer and thinner making them ideal for use in temperature gauges and dials, etc.

Although very cheap and are available over a wide operating range, one main disadvantage of the standard snap-action type thermostats when used as a temperature sensor, is that they have a large hysteresis range from when the electrical contacts open until when they close again. For example, it may be set to 20oC but may not open until 22oC or close again until 18oC.

So the range of temperature swings can be quite high. Commercially available bi-metallic thermostats for home use do have temperature adjustment screws that allow for a more precise desired temperature set-point and hysteresis level to be pre-set.

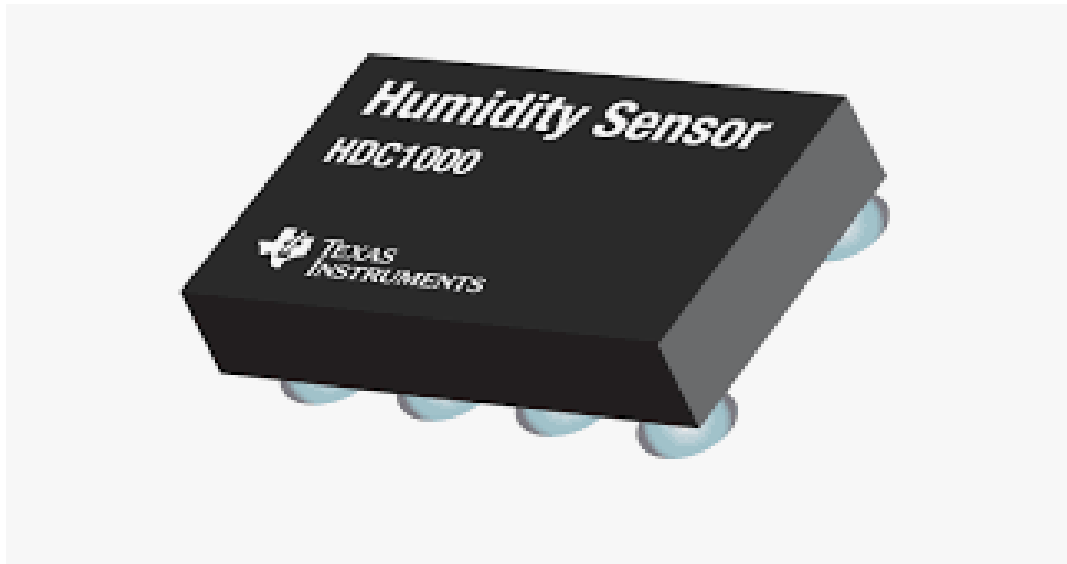
4.3 HUMIDITY SENSOR:

Humidity sensing is essential in such fields as environmental control, process monitoring, and biomedical analysis. A micro fabricated humidity sensor is developed which uses a nitride/silicon microstructure suspended at a small distance above the surface of a glass substrate as the movable electrode of a capacitor and thin-film platinum resistors as temperature sensing elements. The suspending structure is coated with polyimide - a vapour-absorbent polymer film. Moisture-dependent bending of the micro-cantilever is caused by the variation of humidity. The measured capacitance between the micro suspending structure and the substrate is changed.

The humidity sensor is integrated with a platinum resistor as a micro temperature detector for compensation of the capacitance signal drift caused by temperature. A low hysteresis value is indicated at high relative humidity. Because of the large electrode area on the micro cantilever tip and the low stiffness of the micro cantilever, a high degree of sensitivity is also attained. The relative humidity and calibrated capacitance/resistance are documented and both the simulated and experimental samples indicate high stability and a high degree of linearity. The

average time constant of the proposed micro cantilever-based humidity sensors is 1.10 sec in the relative humidity range of 20 %R.H. to 40 %R.H.

ST's digital humidity and temperature sensor is based on a planar capacitance technology that integrates the temperature and humidity sensors in the sensing element



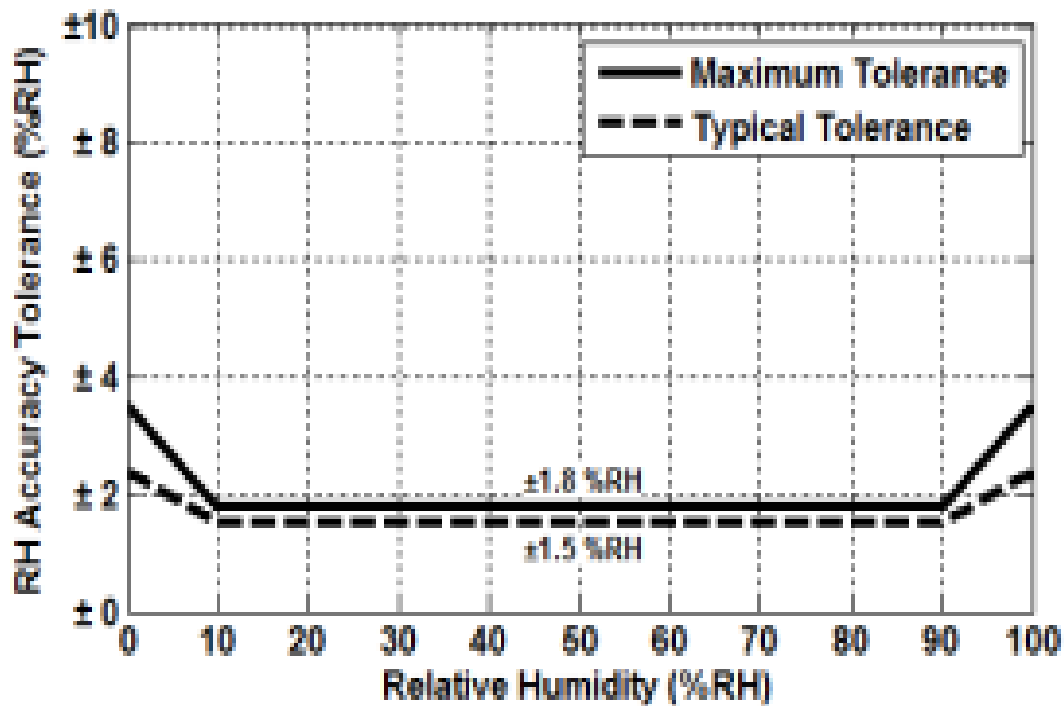
The MVH3201D is the highest accuracy miniature digital relative humidity and temperature sensor in the world. It is well-suited for the most stringent accuracy applications, where sensor performance needs to be best-in-class under a wide range of environmental conditions.

Humidity and temperature are some of the basic weather parameters that play a significant role in human life and its environment.

APPLICATIONS OF HUMIDITY SENSORS:

- The applications of humidity sensors range far and wide. For people with illnesses affected by humidity, monitoring and preventive measure in homes employ humidity sensors.
- A humidity sensor is also found as part of home heating, ventilating and air conditioning systems (HVAC systems). These are also used in offices,

cars, humidors, museums, industrial spaces, and greenhouses and are also used in meteorology stations to report and predict the weather.



4.4 PH SENSOR

pH, commonly used for water measurements, is a measure of acidity and alkalinity, or the caustic and base present in a given solution. It is generally expressed with a numeric scale ranging from 0-14. The value 7 represents neutrality. The numbers on the scale increase with increasing alkalinity, while the numbers on the scale decrease with increasing acidity. Each unit of change represents a tenfold change in acidity or alkalinity. The pH value is also equal to the negative logarithm of the hydrogen-ion concentration or hydrogen-ion activity. pH values for some common solutions are listed in the table to the right.

Combination pH Sensors

The most common method of measuring pH is to use an electrochemical pH sensor. Combination pH sensors are a type of electrochemical pH sensor that features both a measuring electrode and a reference electrode. The measuring electrode detects changes in the pH value while the reference provides a stable signal for comparison. A high impedance device, known as a pH meter, is used to display the millivolt signal in pH units. Combination pH sensor technology can be used to build different products, including laboratory pH sensors and industrial or process pH sensors.



Common Applications:

- pH neutralization of effluent in industrial manufacturing environments
- Cooling tower and boiler control
- Environmental monitoring
- Odour scrubbers
- Food and beverage quality control and safety

- Upstream protection of filtration membranes
- Water pre-treatment for manufacturing processes
- Swimming pool control
- Pulp and paper manufacturing
- Pharmaceutical research & development and manufacturing
- Blood-gas analysis in medical devices

OPERATION

Principle of operation

Potentiometric pH meters measure the voltage between two electrodes and display the result converted into the corresponding pH value. They comprise a simple electronic amplifier and a pair of electrodes, or a combination electrode, and some form of display calibrated in pH units. It usually has a glass electrode and a reference electrode, or a combination electrode. The electrodes, or probes, are inserted into the solution to be tested.[8]

The design of the electrodes is the key part: These are rod-like structures usually made of glass, with a bulb containing the sensor at the bottom. The glass electrode for measuring the pH has a glass bulb specifically designed to be selective to hydrogen-ion concentration. On immersion in the solution to be tested, hydrogen ions in the test solution exchange for other positively charged ions on the glass bulb, creating an electrochemical potential across the bulb. The electronic amplifier detects the difference in electrical potential between the two electrodes generated in the measurement and converts the potential difference to pH units. The magnitude of the electrochemical potential across the glass bulb is linearly related to the pH according to the Nernst equation.

The reference electrode is insensitive to the pH of the solution, being composed of a metallic conductor, which connects to the display. This conductor is immersed in an electrolyte solution, typically potassium chloride, which comes into contact with the test solution through a porous ceramic membrane. The display consists of a voltmeter, which displays voltage in units of pH.

On immersion of the glass electrode and the reference electrode in the test solution, an electrical circuit is completed, in which there is a potential difference created and detected by the voltmeter. The circuit can be thought of as going from the conductive element of the reference electrode to the surrounding potassium-chloride solution, through the ceramic membrane to the test solution, the hydrogen-ion-selective glass of the glass electrode, to the solution inside the glass electrode, to the silver of the glass electrode, and finally the voltmeter of the display device.[9] The voltage varies from test solution to test solution depending on the potential difference created by the difference in hydrogen-ion concentrations on each side of the glass membrane between the test solution and the solution inside the glass electrode. All other potential differences in the circuit do not vary with pH and are corrected for using the calibration.

For simplicity, many pH meters use a combination probe, constructed with the glass electrode and the reference electrode contained within a single probe. A detailed description of combination electrodes is given in the article on glass electrodes.

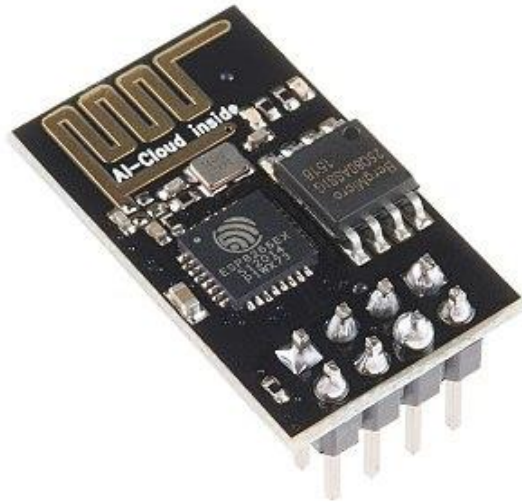
The pH meter is calibrated with solutions of known pH, typically before each use, to ensure accuracy of measurement. To measure the pH of a solution, the electrodes are used as probes, which are dipped into the test solutions and held there sufficiently long for the hydrogen ions in the test solution to equilibrate with the ions on the surface of the bulb on the glass electrode. This equilibration provides a stable pH measurement.

4.5 NODE MCU ESP8266:

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

ESP 8266 MODULE

The ESP8266 is a low-cost Wi-Fi microchip, with a full TCP/IP stack and microcontroller capability, produced by Espressif Systems^[1] in Shanghai, China. The chip first came to the attention of Western makers in August 2014 with the ESP-01 module, made by a third-party manufacturer Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at first there was almost no English-language documentation on the chip and the commands it accepted. The very low price and the fact that there were very few external components on the module, which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, the chip, and the software on it, as well as to translate the Chinese documentation. The ESP8285 is an ESP8266 with 1 MiB of built-in flash, allowing the building of single-chip devices capable of connecting to Wi-Fi. These microcontroller chips have been succeeded by the ESP32 family of devices, including the pin-compatible ESP32-C3.



ESP8266

FEATURE:

- Processor: L106 32-bit RISC microprocessor core based on the Tensilica Xtensa Diamond Standard 106Micro running at 80 MHz^[5]
- Memory:
 - 32 KiB instruction RAM
 - 32 KiB instruction cache RAM
 - 80 KiB user-data RAM
 - 16 KiB ETS system-data RAM
- External QSPI flash: up to 16 MiB is supported (512 KiB to 4 MiB typically included)
- IEEE 802.11 b/g/n Wi-Fi
 - Integrated TR switch, balun, LNA, Power amplifier and matching network.
 - WEP or WPA/WPA2 authentication, or open networks
- 16 GPIO pins
- SPI

- I²C (software implementation)^[6]
- I²S interfaces with DMA (sharing pins with GPIO)
- UART on dedicated pins, plus a transmit-only UART can be enabled on GPIO2
- 10-bit ADC (successive approximation ADC)

Pinout of ESP

The pinout is as follows for the common ESP-01 module:

- GND, Ground (0 V)
- GPIO 2, General-purpose input/output No. 2
- GPIO 0, General-purpose input/output No. 0
- RX, Receive data bit X, also GPIO3
- VCC, Voltage (+3.3 V; can handle up to 3.6 V)
- RST, Reset
- CH_PD, Chip power-down
- TX, Transmit data bit X, also GPIO1

Espressif modules

This is the series of ESP8266-based modules made by Espressif:

Name	Active pins	Pitch	Form factor	LEDs	Antenna	Shielded	Dimensions (mm)	Notes
ESP-WROOM-02	18	1.5 mm	2×9 castellated	No	PCB trace	Yes	18 × 20	FCC ID 2AC7Z-ESPWROOM02.

ESP-WROOM-02D	18	1.5 mm	2×9 castellated	No	PCB trace	Yes	18 × 20	FCC ID 2AC7Z-ESPWROOM02D. Revision of ESP-WROOM-02 compatible with both 150-mil and 208-mil flash memory chips.
ESP-WROOM-02U	18	1.5 mm	2×9 castellated	No	U.FL socket	Yes	18 × 20	Differs from ESP-WROOM-02D in that includes an U.FL compatible antenna socket connector.

ESP-WROOM-S2	20	1.5 mm	2×10 castellated	No	PCB trace	Yes	16 × 23	FCC ID 2AC7Z-ESPWROOM-S2.
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In the table above (and the two tables which follow), "Active pins" include the GPIO and ADC pins with which external devices can be attached to the ESP8266 MCU. The "Pitch" is the space between pins on the ESP8266 module, which is important to know if the device will be used on a breadboard. The "Form factor" also describes the module packaging as "2 × 9 DIL", meaning two rows of 9 pins arranged "Dual In Line", like the pins of DIP ICs. Many ESP-xx modules include a small on-board LED which can be programmed to blink and thereby indicate activity. There are several antenna options for ESP-xx boards including a trace antenna, an on-board ceramic antenna, and an external connector which allows an external Wi-Fi antenna to be attached. Since Wi-Fi communications generates a lot of RFI (Radio Frequency Interference), governmental bodies like the FCC like shielded electronics to minimize interference with other devices. Some of the ESP-xx modules come housed within a metal box with an FCC seal of approval stamped on it. First and second world markets will likely demand FCC approval and shielded Wi-Fi devices.

Node-MCU ESP8266 Specifications & Features:

- Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106
- Operating Voltage: 3.3V
- Input Voltage: 7-12V
- Digital I/O Pins (DIO): 16

- Analog Input Pins (ADC): 1
- UARTs: 1
- SPIs: 1
- I2Cs: 1
- Flash Memory: 4 MB
- SRAM: 64 KB
- Clock Speed: 80 MHz
- USB-TTL based on CP2102 is included onboard, Enabling Plug n Play
- PCB Antenna
- Small Sized module to fit smartly inside your IoT projects

Brief About NodeMCU ESP8266:

The NodeMCU ESP8266 development board comes with the ESP-12E module containing the ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. NodeMCU has 128 KB RAM and 4MB of Flash memory to store data and programs. Its high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features make it ideal for IoT projects.

NodeMCU can be powered using a Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interfaces.

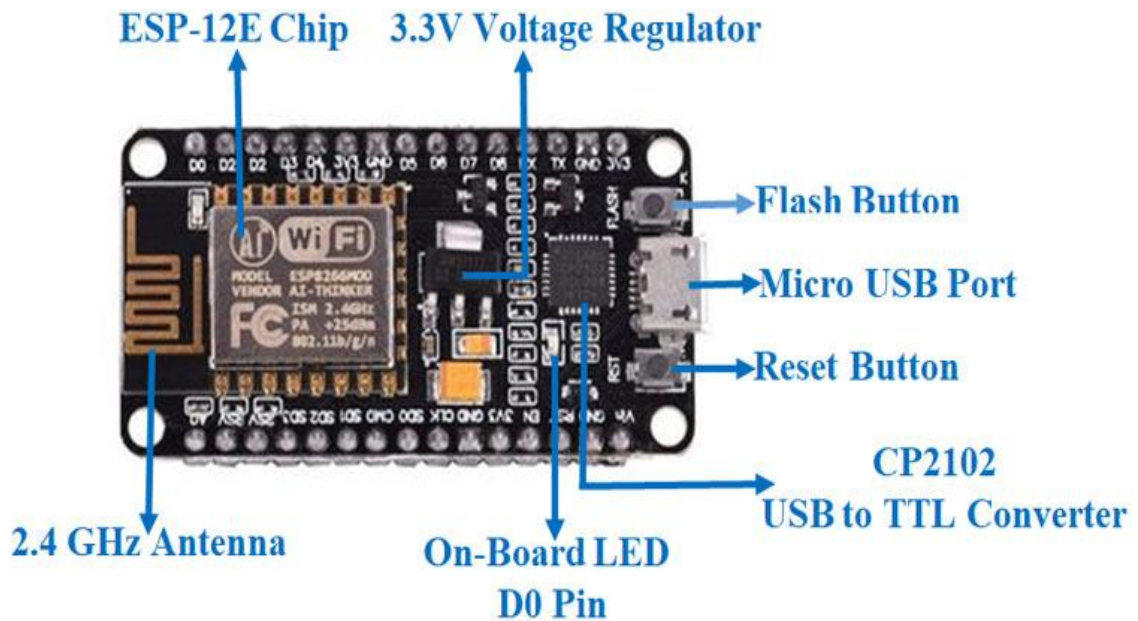


Fig 4.3 NodeMcu diagram

Power Requirement:

As the operating voltage range of ESP8266 is 3V to 3.6V, the board comes with an LDO voltage regulator to keep the voltage steady at 3.3V. It can reliably supply up to 600mA, which should be more than enough when ESP8266 pulls as much as 80mA during RF transmissions. The output of the regulator is also broken out to one of the sides of the board and labeled as 3V3. This pin can be used to supply power to external components.

Power to the ESP8266 NodeMCU is supplied via the onboard MicroB USB connector. Alternatively, if you have a regulated 5V voltage source, the VIN pin can be used to directly supply the ESP8266 and its peripherals.

Peripherals and I/O:

The ESP8266 NodeMCU has a total of 17 GPIO pins broken out to the pin headers on both sides of the development board. These pins can be assigned to all sorts of peripheral duties, including:

- ADC channel – A 10-bit ADC channel.
- UART interface – UART interface is used to load code serially.
- PWM outputs – PWM pins for dimming LEDs or controlling motors.
- SPI, I2C & I2S interface – SPI and I2C interface to hook up all sorts of sensors and peripherals.
- I2S interface – I2S interface if you want to add sound to your project.

Onboard Switches & LED Indicator:

The ESP8266 NodeMCU features two buttons. One marked as RST located on the top left corner is the Reset button, used of course to reset the ESP8266 chip. The other FLASH button on the bottom left corner is the download button used while upgrading firmware.

The board also has a LED indicator that is user programmable and is connected to the D0 pin of the board.

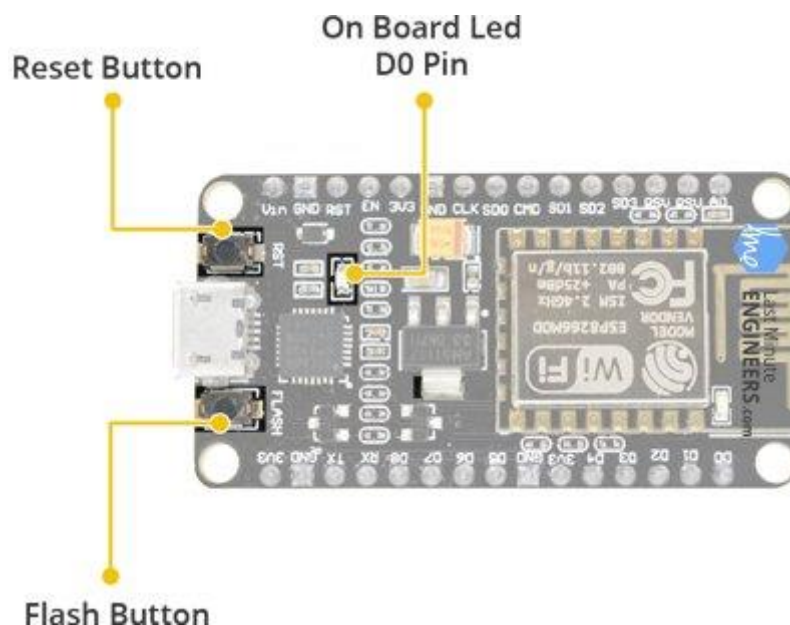


Fig 4.4 Switch diagram

Serial Communication:

The board includes a CP2102 USB-to-UART Bridge Controller from

Silicon Labs, which converts USB signal to serial and allows your computer to program and communicate with the ESP8266 chip.

USB To TTL Converter
CP2102

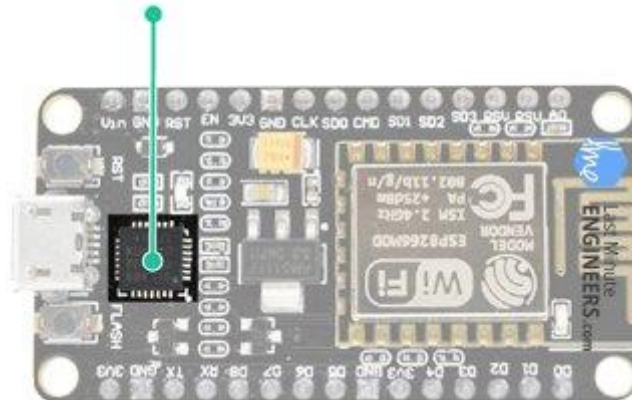
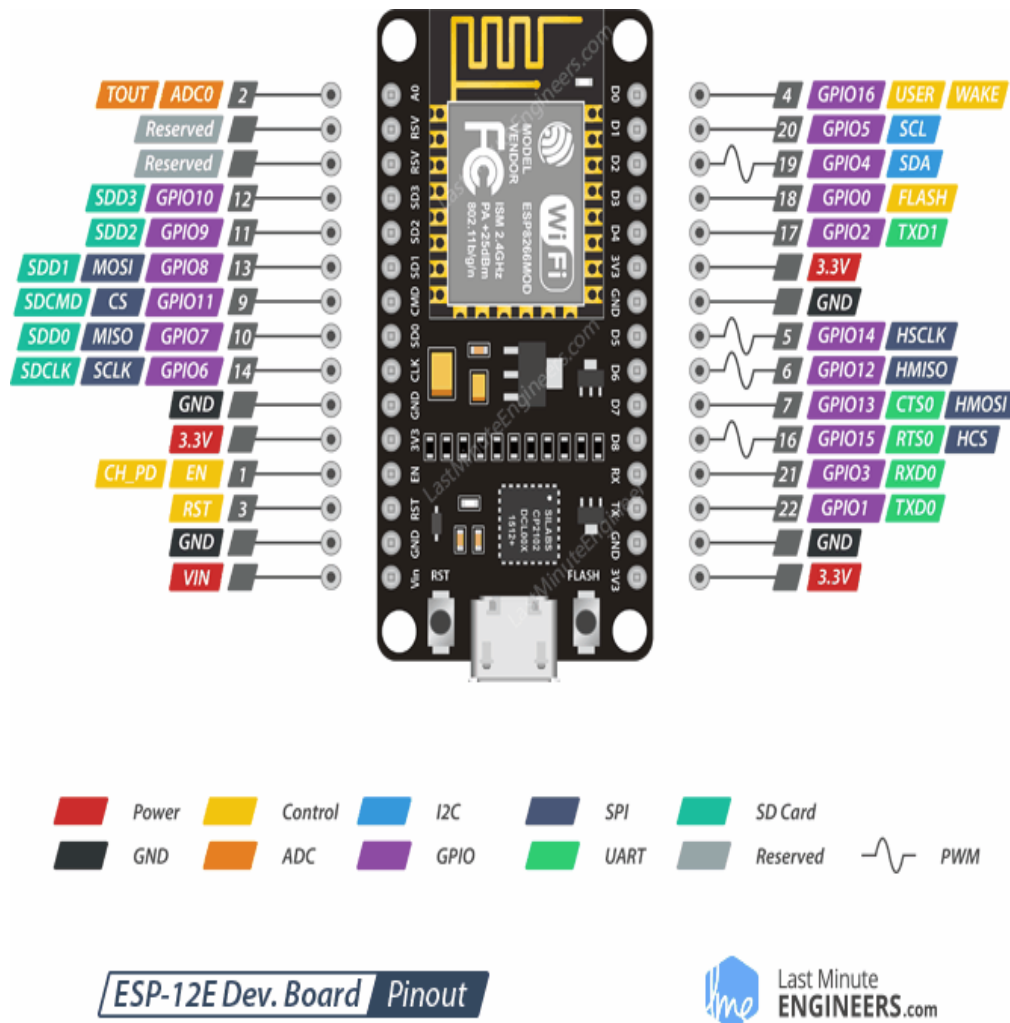


Fig 4.5 Serial communication diagram

If you have an older version of the CP2102 driver installed on your PC, we recommend upgrading now.

ESP8266 NodeMCU Pinout:

The ESP8266 NodeMCU has a total of 30 pins that interface it to the outside world. The connections are as follows:



I2C Pins:

I2C Pins are used to hooking up all sorts of I2C sensors and peripherals in your project. Both I2C Master and I2C Slave are supported. I2C interface functionality can be realized programmatically, and the clock frequency is 100 kHz at a maximum. It should be noted that the I2C clock frequency should be higher than the slowest clock frequency of the slave device.

GPIO Pins:

ESP8266 NodeMCU has 17 GPIO pins which can be assigned to various functions such as I2C, I2S, UART, PWM, IR Remote Control, LED Light, and Button programmatically. Each digital-enabled GPIO can be configured to internal pull-up or pull-down, or set to high impedance. When configured as an input, it can also be set to edge-trigger or level-trigger to generate CPU interrupts.

ADC Channel:

The NodeMCU is embedded with a 10-bit precision SAR ADC. The two functions can be implemented using ADC viz. Testing power supply voltage of VDD3P3 pin and testing input voltage of TOUT pin. However, they cannot be implemented at the same time.

UART Pins:

ESP8266 NodeMCU has 2 UART interfaces, i.e. UART0 and UART1, which provide asynchronous communication (RS232 and RS485) and can communicate at up to 4.5 Mbps. UART0 (TXD0, RXD0, RST0 & CTS0 pins) can be used for communication. It supports flow control. However, UART1 (TXD1 pin) features only data transmit signal so, it is usually used for printing log.

SPI Pins:

ESP8266 features two SPIs (SPI and HSPI) in slave and master modes. These SPIs also support the following general-purpose SPI features:

- 4 timing modes of the SPI format transfer
- Up to 80 MHz and the divided clocks of 80 MHz
- Up to 64-Byte FIFO

SDIO Pins:

ESP8266 features a Secure Digital Input/Output Interface (SDIO) which is used to directly interface SD cards. 4-bit 25 MHz SDIO v1.1 and 4-bit 50 MHz SDIO v2.0 are supported.

PWM Pins:

The board has 4 channels of Pulse Width Modulation (PWM). The PWM output can be implemented programmatically and used for driving digital motors and LEDs. PWM frequency range is adjustable from 1000 μ s to 10000 μ s, i.e., between 100 Hz and 1 kHz.

Control Pins:

Control pins are used to control ESP8266. These pins include Chip Enable pin (EN), Reset pin (RST), and WAKE pin.

EN pin – The ESP8266 chip is enabled when the EN pin is pulled HIGH. When pulled LOW the chip works at minimum power.

- RST pin – RST pin is used to reset the ESP8266 chip.
- WAKE pin – Wake pin is used to wake the chip from deep-sleep
- **VIBRATION MOTORS:**
- There are two basic types of vibration motor. An eccentric rotating mass vibration motor (ERM) uses a small unbalanced mass on a DC motor when it rotates it creates a force that translates to vibrations. A linear resonant actuator (LRA) contains a small internal mass attached to a spring, which

creates a force when driven. As specialists in the supply and design of vibration motors, you can find our stocked motors in our product catalog. If you can't find exactly what you need or would like to discuss a project, please do not hesitate to contact our engineers here. If you prefer to read online, you will find lots of additional information and guides to help you understand how vibration motors work.



CHAPTER-5

SOFTWARE REQUIREMENTS AND PROCESS

5.1 EMBEDDED C:

Embedded C is the most popular programming language in the software field for developing electronic gadgets. Each processor used in an electronic system is associated with embedded software.

Embedded C programming plays a key role in performing specific functions by the processor. In day-to-day life, we used many electronic devices such as mobile phones, washing machines, digital cameras, etc. These all device working is based on a microcontroller that is programmed by embedded C.

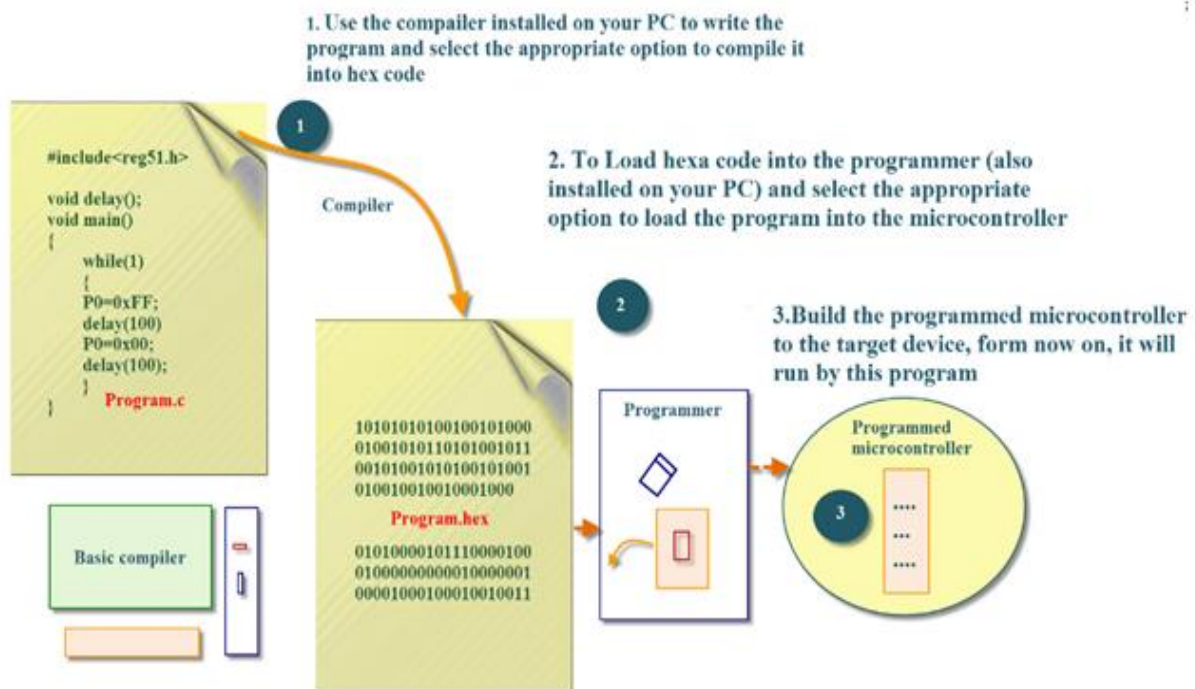


Fig 5.1 Block diagram of Embedded C

The Embedded C code written in the above block diagram is used for blinking the LED connected with Port0 of a microcontroller.

In an embedded system, programming C code is preferred over other languages. Due to the following reasons:

- Easy to understand
- High Reliability
- Portability
- Scalability

A function is a collection of statements that are used for performing a specific task and a collection of one or more functions is called a programming language.

Most consumers are familiar with application software that provide functionality on a computer. Embedded software however is often less visible, but no less complicated. Unlike application software, embedded software has fixed hardware requirements and capabilities, and the addition of third-party hardware or software is strictly controlled.

Embedded software needs to include all needed device drivers at manufacturing time, and the device drivers are written for the specific hardware. The software is highly dependent on the CPU and specific chips were chosen. Most embedded software engineers have at least a passing knowledge of reading schematics and reading datasheets for components to determine the usage of registers and communication systems. Conversion between decimal, hexadecimal, and binary is useful as well as using bit manipulation.

Web applications are rarely used, although XML files and other output may be passed to a computer for display. File systems with folders are typically absent as are SQL databases.

Software development requires the use of a cross compiler, which runs on a computer but produces executable code for the target device. Debugging requires the use of an in-circuit emulator, JTAG or SWD. Software developers often have access to the complete kernel (OS) source code.

The size of the storage memory and RAM can vary significantly. Some systems run in 16 KB of Flash and 4 KB of RAM with a CPU operating at 8 MHz, other systems can rival contemporary computers.[8] These space requirements lead to more work being done in C or embedded C++, instead of C++. Interpreted languages like BASIC (while e.g. Parallax Propeller can use compiled BASIC) and Java (Java ME Embedded 8.3[9] is available e.g. ARM Cortex-M4, Cortex-M7 microcontrollers, and older ARM11 used in Raspberry Pi and Intel Galileo Gen. 2) are not commonly used; while implementation of the interpreted Python 3 language – MicroPython – is however available expressly for microcontroller use, e.g. 32-bit ARM-based (such as BBC micro: bit) and 16-bit PIC microcontrollers.

Communications between processors and between one processor and other components are essential. Besides direct memory addressing, common protocols include I²C, SPI, serial ports, and USB.

Communications protocols designed for use in embedded systems are available as closed source from companies including InterNiche Technologies and CMX Systems. Open-source protocols stem from uIP, lwip, and others

- This program explains how to use structure within the structure in C using normal variable. “student_college_detail” structure is declared inside “student_detail” structure in this program. Both structure variables Please note that members of “student_college_detail” structure are accessed by 2 dots (.) operator and members of “student are normal structure variables.
- _detail” structure is accessed by a single dot(.) operator.

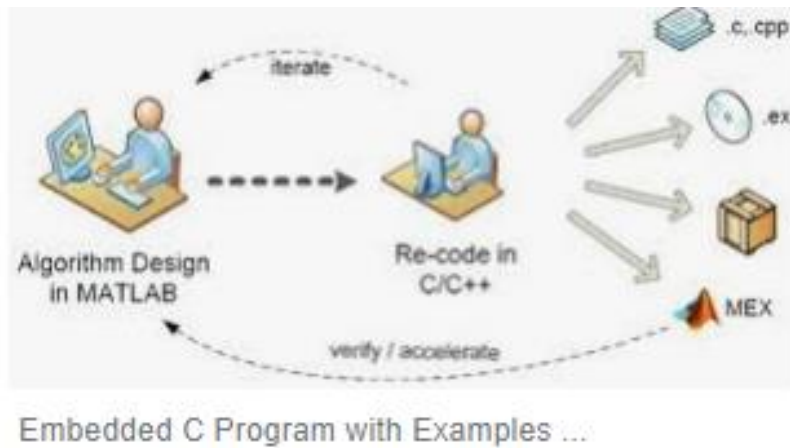


Fig 5.2 Embedded C program with examples

A Keyword is a special word with a special meaning to the compiler (a C Compiler, for example, is software that is used to convert programs written in C to Machine Code). For example, if we take Keil's Cx51 Compiler (a popular C Compiler for 8051 based Microcontrollers) the following are some of the keywords:

- bit
- sbit
- SFR
- small
- large

These are a few of the many keywords associated with the Cx51 C Compiler along with the standard C Keywords.

5.2 ARDUINO IDE:

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

The Arduino platform has become quite popular with people just starting with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) to load new code onto the board – you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package.

The Arduino hardware and software were designed for artists, designers, hobbyists, hackers, newbies, and anyone interested in creating interactive objects or environments. Arduino can interact with buttons, LEDs, motors, speakers, GPS units, cameras, the internet, and even your smartphone or your TV! This flexibility combined with the fact that the Arduino software is free, the hardware boards are pretty cheap, and both the software and hardware are easy to learn has led to a large community of users who have contributed code and released instructions for a **huge** variety of Arduino-based projects

There are many varieties of Arduino boards (explained on the next page) that can be used for different purposes. Some boards look a bit different from the one below, but most Arduinos have the majority of these components in common:



Fig 5.3 Arduino IDE Diagram

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches and open the serial monitor

The Arduino IDE is incredibly minimalistic, yet it provides a near-complete environment for most Arduino-based projects. The top menu bar has the standard options, including “File” (new, load save, etc.), “Edit” (font, copy, paste, etc.), “Sketch” (for compiling and programming), “Tools” (useful options for testing projects), and “Help”. The middle section of the IDE is a simple text editor that where you can enter the program code. The bottom section of the IDE is dedicated to an output window that is used to see the status of the compilation, how much memory has been used, any errors that were found in the program, and various other useful messages.

Projects made using the Arduino are called sketches, and such sketches are usually written in a cut-down version of C++ (several C++ features are not included). Because programming a microcontroller is somewhat different from programming a computer, there are several device-specific libraries (e.g., changing pin modes, output data on pins, reading analog values, and timers). This sometimes confuses users who think Arduino is programmed in an “Arduino language.” However, the Arduino is programmed in C++. It just uses unique libraries for the device.

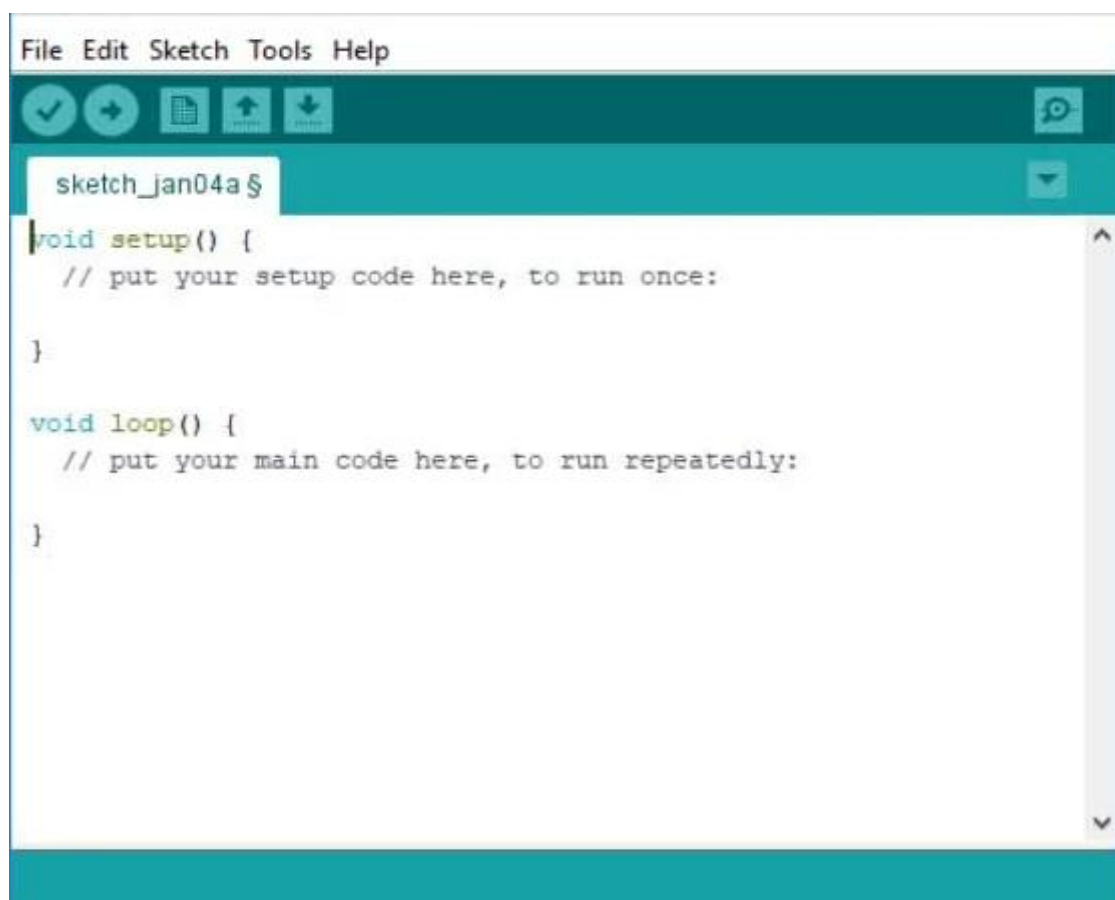


Fig 5.4 Arduino IDE Software diagram

The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that is compiled and linked with a program

stub *main()* into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program *avrdude* to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

Programming the Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the Tools > Board menu (according to the microcontroller on your board). For details, see the reference and tutorials. The ATmega328 on the Arduino Uno comes pre burned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files). You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details. The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2/8U2 is loaded with a DFU bootloader, which can be activated by:

- On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.
- On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader). See this user-contributed tutorial for more information. Automatic (Software) Reset Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer.

One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following halfsecond or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data. The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

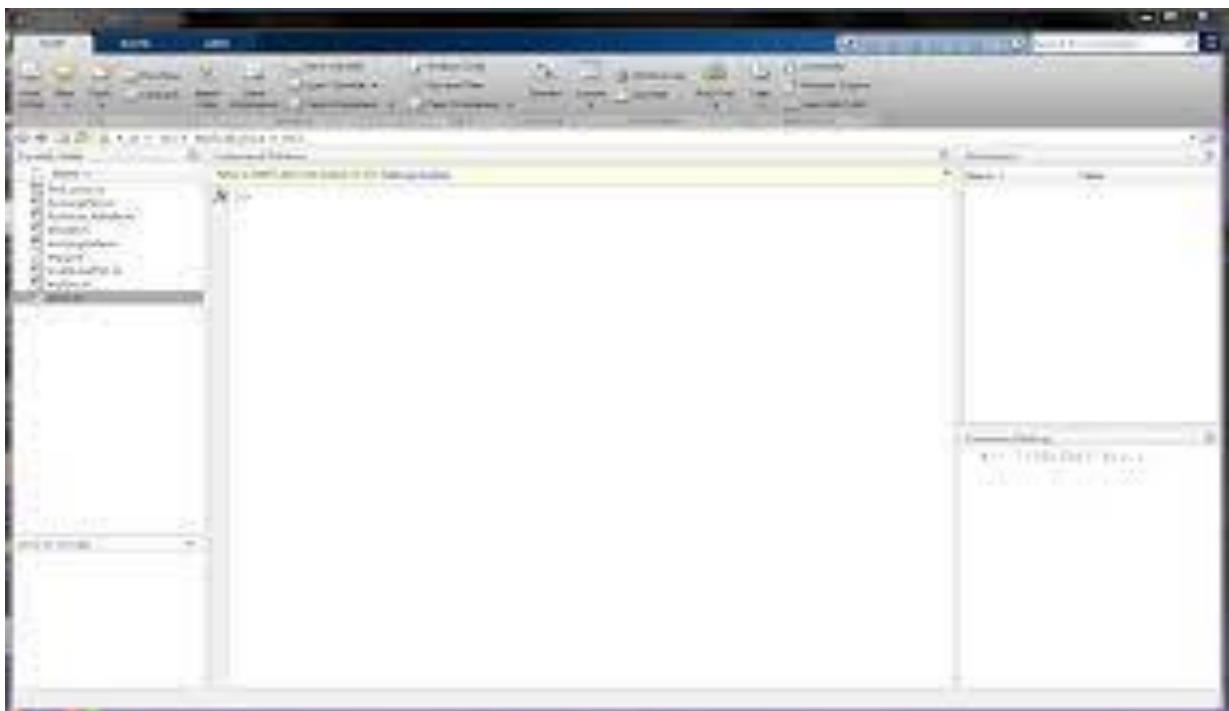
5.3 LSTM:

- Long short-term memory (LSTM) is an artificial recurrent neural network (RNN) architecture used in the field of deep learning. Unlike standard feedforward neural networks, LSTM has feedback connections. It can process not only single data points (such as images), but also entire sequences of data (such as speech or video).
- A common LSTM unit is composed of a cell, an input gate, an output gate and a forget gate. The cell remembers values over arbitrary time intervals and the three gates regulate the flow of information into and out of the cell.

- LSTM networks are well-suited to classifying, processing and making predictions based on time series data, since there can be lags of unknown duration between important events in a time series. LSTMs were developed to deal with the vanishing gradient problem that can be encountered when training traditional RNNs. Relative insensitivity to gap length is an advantage of LSTM over RNNs, hidden Markov models and other sequence learning methods in numerous applications.
- The success of LSTMs is in their claim to be one of the first implements to overcome the technical problems and deliver on the promise of recurrent neural networks. The two technical problems overcome by LSTMs are vanishing gradients and exploding gradients, both related to how the network is trained.

MATLAB:

MATLAB is a proprietary multi-paradigm programming language and numeric computing environment developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages.



5.4 SETUP:

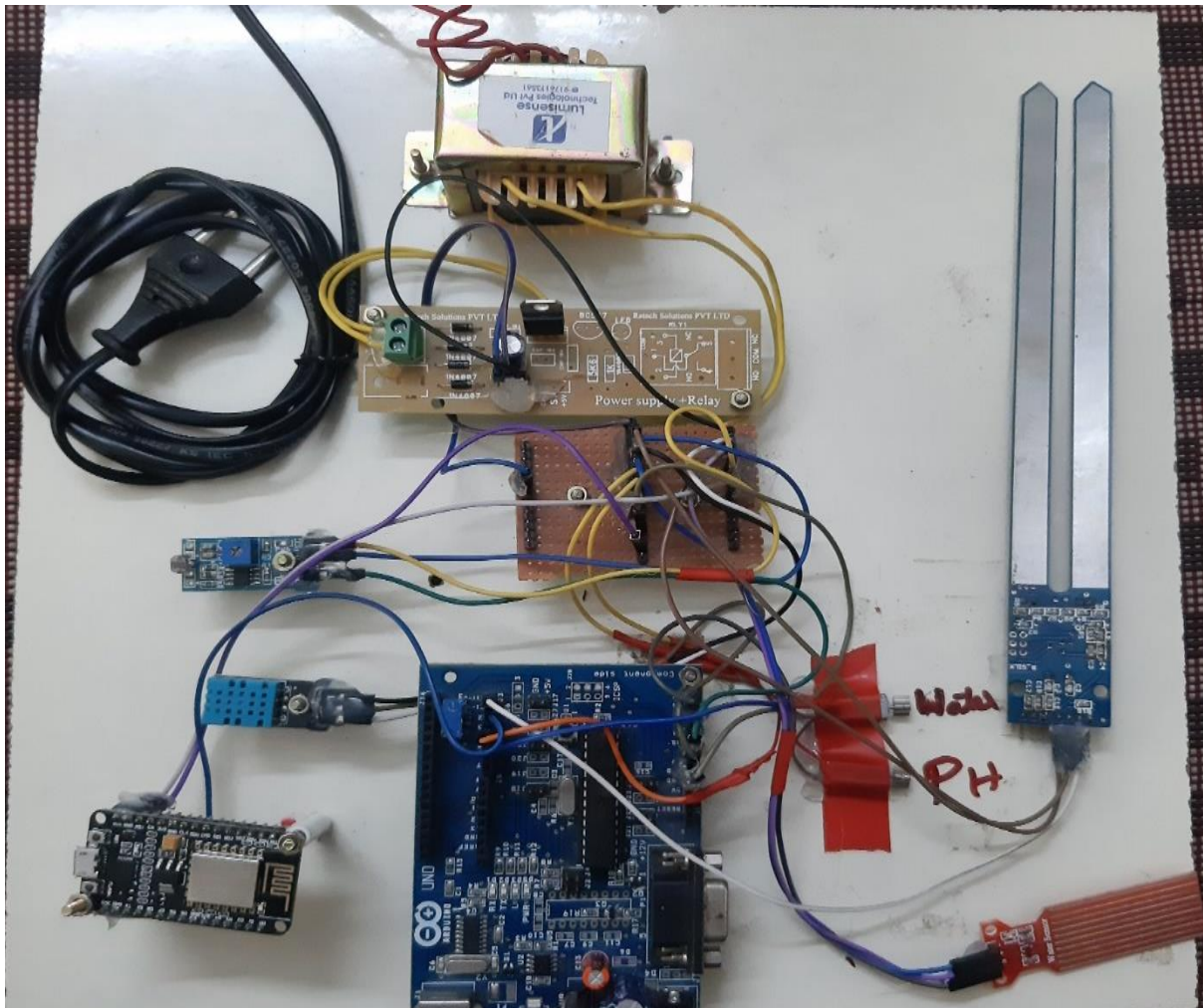
Sowing in germination trays



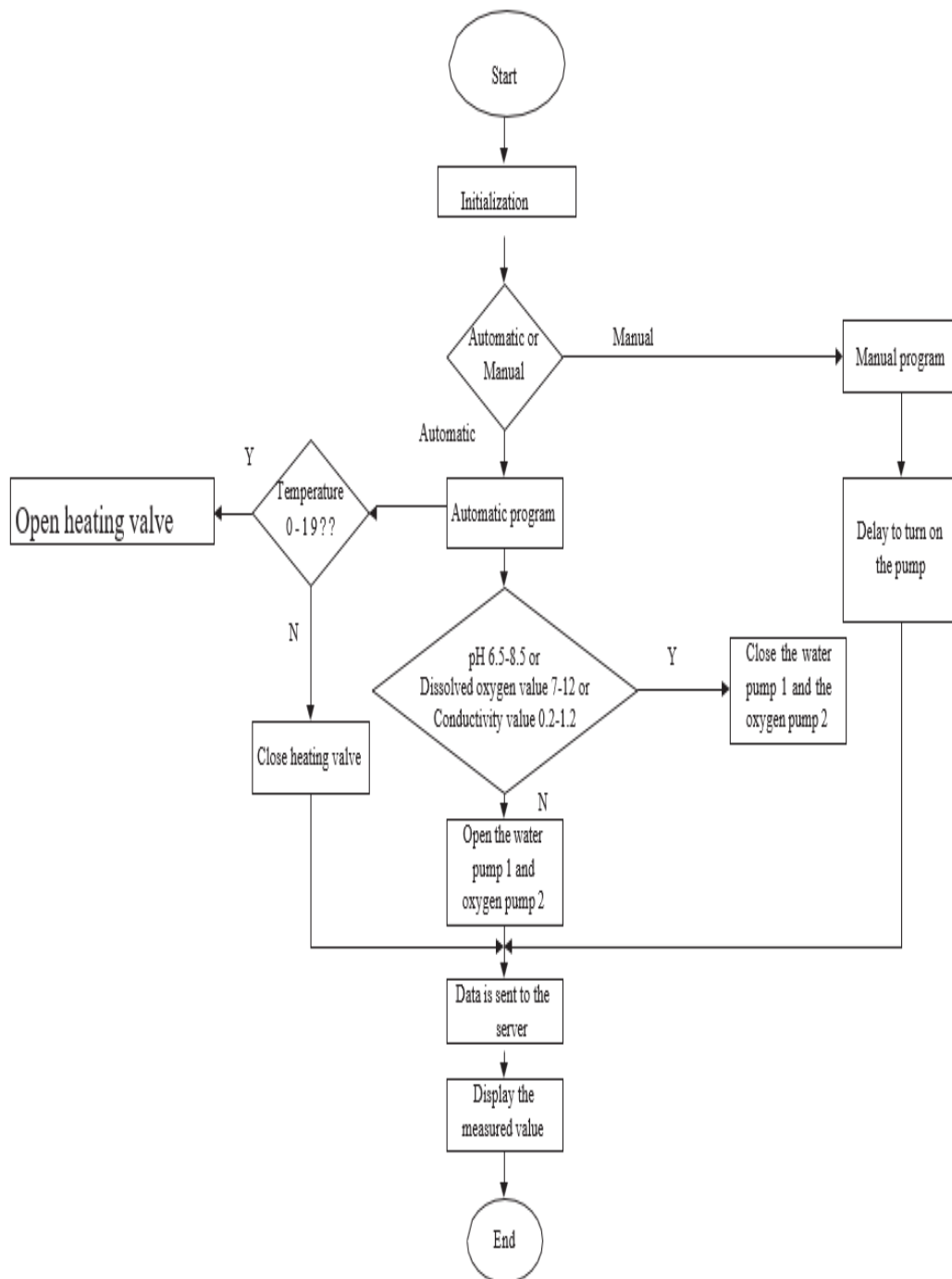
Mini plant setup for growing hydroponically



5.5 HARDWARE SETUP:



5.6 FLOW CHART:



5.7 CODE:

```
#include <dht.h>

#define dht_apin A0 // Analog Pin sensor is connected to

#define water A5

#define ldr A2

#define water_pump 3

#define motor 4

float phvalue;

unsigned long int Time;

dht DHT;

void setup(){

    Serial.begin(9600);

    delay(1000);

    pinMode(ldr,INPUT);

    pinMode(water,INPUT);

    pinMode(water_pump,OUTPUT);

    pinMode(motor,OUTPUT);

}

void loop(){

    String phdata = Serial.readStringUntil(':');

    if(phdata != "")

    {
```

```

String ph = Serial.readStringUntil('$');

phvalue=ph.toFloat();

Serial.println("PH Value");

Serial.println(phvalue);

Serial.println(ph);

delay(1000);

}

int a=analogRead(water);

a = map(a,0, 750, 0, 100);

Serial.print("water level=");

Serial.println(a);

int b=analogRead(ldr);

b = map(b, 1023, 100, 0, 100);

Serial.print("light level=");

Serial.println(b);

DHT.read11(dht_apin);

Serial.print("Current humidity = ");

Serial.print(DHT.humidity);

Serial.print("% ");

Serial.print("temperature = ");

Serial.print(DHT.temperature);

Serial.println("C ");

```

```

    delay(1500);
if((a<60)&&(a!=0))
{
    digitalWrite(water_pump,HIGH);
    Serial.println("WATER PUMP ON");
}
else
{
    digitalWrite(water_pump,LOW);
    Serial.println("WATER PUMP OFF");
}
f(phvalue<12)
{
    digitalWrite(motor,LOW);
    Serial.println("motor OFF");
}
else
{
    digitalWrite(motor,HIGH);
    Serial.println("motor ON");
}
Serial.println("-----");}

```

CHAPTER 6

RESULTS AND ANALYSIS

6.1 Inputs from Arduino:

S.No	Temperature in C	Humidity in %	PH	Waterlevel	LDR	Motor status	Water Pump
1	29	65	6.9	77	17	OFF	OFF
2	28	66	7	74	17	OFF	OFF
3	27	66	7	69	17	OFF	OFF
4	27	62	8	78	17	OFF	OFF
5	27	60	7	74	17	OFF	OFF
6	27	59	7	76	17	OFF	OFF
7	31	60	7	71	17	OFF	OFF
8	29	66	8	75	17	OFF	OFF
9	31	60	7	79	17	OFF	OFF
10	26	59	7.5	77	17	OFF	OFF
11	25	59	7.3	66	16	OFF	OFF
12	31	65	7.6	67	16	OFF	OFF
13	30	64	7.6	77	16	OFF	OFF
14	27	61	7.4	69	16	OFF	OFF
15	27	60	7.6	68	16	OFF	OFF
16	26	66	7.2	78	16	OFF	OFF
17	29	66	6.9	80	16	OFF	OFF
18	30	63	7.8	68	16	OFF	OFF
19	27	59	8	68	16	OFF	OFF
20	30	60	8	81	16	OFF	OFF
21	26	66	8	79	16	OFF	OFF
22	30	65	7.4	70	16	OFF	OFF
23	28	62		77	16	OFF	OFF
24	27	59	7.6	71	16	OFF	OFF
25	16	78	9.6	76	16	ON	ON
26	22	51	8.5	65	16	OFF	OFF
27	28	57	7.1	73	16	OFF	OFF
28	22	61	7.3	71	16	OFF	OFF
29	27	58	8.6	65	16	OFF	OFF
30	23	63	7.4	73	16	OFF	OFF
31	24	58	7.1	66	16	OFF	OFF
32	24	62	7.3	73	14	OFF	OFF
33	29	55	8.4	68	14	OFF	OFF
34	28	62	7.9	71	14	OFF	OFF
35	28	63	8.3	73	14	OFF	OFF
36	22	61	7.5	76	14	OFF	OFF
37	27	56	7.8	68	14	OFF	OFF
38	23	56	7.4	71	14	OFF	OFF

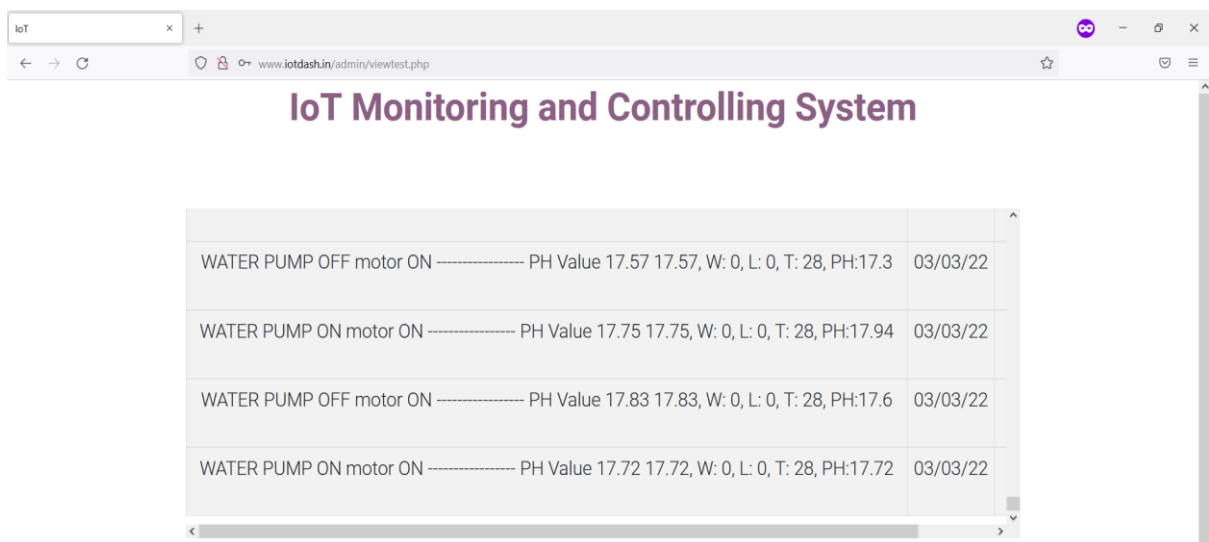
39	27	61	7.1	67	14	OFF	OFF
40	26	62	8.5	66	14	OFF	OFF
41	26	60	8.6	70	14	OFF	OFF
42	27	57	7.8	66	14	OFF	OFF
43	24	60	7.8	73	14	OFF	OFF
44	25	55	7.2	68	14	OFF	OFF
45	26	56	8.1	67	13	OFF	OFF
46	27	52	7.6	76	13	OFF	OFF
47	29	59	7.4	65	13	OFF	OFF
48	29	54	8.4	76	13	OFF	OFF
49	28	52	7.7	70	13	OFF	OFF
50	29	60	8.6	74	13	OFF	OFF
51	28	63	9.0	71	13	OFF	OFF
52	24	57	7.2	66	13	OFF	OFF
53	26	53	7.8	66	13	OFF	OFF
54	26	56	7.9	69	13	OFF	OFF
55	26	61	7.6	73	13	OFF	OFF
56	29	61	7.3	70	13	OFF	OFF
57	29	56	7.1	69	13	OFF	OFF
58	28	54	7.4	65	13	OFF	OFF
59	25	60	7.8	70	13	OFF	OFF
60	26	59	8.8	66	13	OFF	OFF
61	22	62	8.0	72	13	OFF	OFF
62	24	52	8.8	72	13	OFF	OFF
63	23	58	7.4	65	13	OFF	OFF
64	22	61	8.5	69	13	OFF	OFF
65	23	54	8.9	67	13	OFF	OFF
66	24	62	8.5	65	13	OFF	OFF
67	24	58	8.2	72	13	OFF	OFF
68	29	51	7.1	69	13	OFF	OFF
69	24	60	7.4	74	13	OFF	OFF
70	25	60	8.6	70	13	OFF	OFF
71	28	59	8.9	75	13	OFF	OFF
72	23	60	7.9	74	13	OFF	OFF
73	24	60	8.6	72	13	OFF	OFF
74	28	51	8.2	69	13	OFF	OFF
75	25	57	8.3	75	13	OFF	OFF
76	22	52	8.1	75	13	OFF	OFF
77	28	53	8.0	68	13	OFF	OFF
78	28	52	7.6	72	13	OFF	OFF
79	22	59	7.7	74	13	OFF	OFF
80	29	60	7.4	76	13	OFF	OFF
81	24	61	7.3	70	13	OFF	OFF
82	22	62	8.3	65	13	OFF	OFF
83	24	58	8.8	68	13	OFF	OFF
84	28	56	8.3	67	13	OFF	OFF

85	23	57	7.3	74	13	OFF	OFF
86	25	59	7.7	73	13	OFF	OFF
87	23	60	7.2	74	13	OFF	OFF
88	27	59	8.6	74	13	OFF	OFF
89	23	56	8.5	65	13	OFF	OFF
90	28	57	7.2	71	13	OFF	OFF
91	23	53	7.1	67	13	OFF	OFF
92	28	56	8.4	71	13	OFF	OFF
93	29	51	8.1	65	13	OFF	OFF
94	23	56	8.6	73	13	OFF	OFF
95	27	59	8.6	76	13	OFF	OFF
96	24	54	7.1	66	13	OFF	OFF
97	28	62	8.9	75	13	OFF	OFF
98	26	63	7.7	74	13	OFF	OFF
99	26	54	8.2	72	13	OFF	OFF
100	24	51	8.0	76	13	OFF	OFF
101	29	59	7.6	66	13	OFF	OFF
102	24	53	7.6	66	13	OFF	OFF
103	25	59	8.4	69	13	OFF	OFF
104	22	54	8.1	76	13	OFF	OFF
105	22	62	8.8	72	13	OFF	OFF
106	22	57	7.9	71	13	OFF	OFF
107	24	58	7.3	67	13	OFF	OFF
108	24	61	7.6	73	13	OFF	OFF
109	24	53	8.3	72	13	OFF	OFF
110	22	64	7.1	22	13	ON	ON
111	27	59	8.8	75	13	OFF	OFF
112	27	65	8.8	66	13	OFF	OFF
113	24	60	7.1	77	12	OFF	OFF
114	29	67	8.7	78	12	OFF	OFF
115	29	66	7.6	70	12	OFF	OFF
116	30	64	7.9	76	12	OFF	OFF
117	28	65	8.3	72	12	OFF	OFF
118	26	65	7.9	69	12	OFF	OFF
119	27	63	7.1	74	12	OFF	OFF
120	24	59	7.8	67	12	OFF	OFF
121	25	67	7.1	65	12	OFF	OFF
122	27	67	7.8	67	12	OFF	OFF
123	25	64	9.0	67	12	OFF	OFF
124	27	63	7.4	76	12	OFF	OFF
125	28	63	7.9	76	12	OFF	OFF
126	26	60	8.1	69	12	OFF	OFF
127	29	61	7.0	72	12	OFF	OFF
128	25	67	7.8	67	12	OFF	OFF
129	30	61	8.0	66	12	OFF	OFF
130	29	62	8.1	76	12	OFF	OFF

131	26	64	7.9	77	12	OFF	OFF
132	27	64	7.2	77	12	OFF	OFF
133	29	62	7.6	65	12	OFF	OFF
134	29	64	7.9	75	12	OFF	OFF
135	30	61	8.2	72	12	OFF	OFF
136	25	67	8.9	76	12	OFF	OFF
137	29	63	8.9	65	12	OFF	OFF
138	27	65	7.1	68	12	OFF	OFF
139	30	61	7.6	71	12	OFF	OFF
140	24	66	8.9	77	12	OFF	OFF
141	28	63	7.7	70	12	OFF	OFF
142	28	66	8.1	77	12	OFF	OFF
143	27	59	7.1	65	12	OFF	OFF
144	28	64	8.7	67	12	OFF	OFF
145	24	67	7.8	76	10	OFF	OFF
146	29	60	7.0	70	10	OFF	OFF
147	27	59	7.9	75	10	OFF	OFF
148	29	60	8.8	73	10	OFF	OFF
149	25	59	7.1	76	10	OFF	OFF
150	25	61	8.0	69	10	OFF	OFF
151	29	59	7.6	70	10	OFF	OFF
152	29	66	7.1	65	10	OFF	OFF
153	24	64	8.6	71	10	OFF	OFF
154	29	67	7.6	78	10	OFF	OFF
155	30	59	7.2	65	8	OFF	OFF
156	26	62	8.8	70	8	OFF	OFF
157	28	60	7.8	78	8	OFF	OFF
158	26	63	7.3	70	8	OFF	OFF
159	30	59	8.4	76	8	OFF	OFF
160	28	60	7.7	65	8	OFF	OFF
161	30	61	7.9	71	8	OFF	OFF
162	27	61	8.2	76	8	OFF	OFF
163	30	64	7.1	69	8	OFF	OFF
164	26	63	8.1	70	8	OFF	OFF
165	27	59	7.6	67	8	OFF	OFF
166	30	67	8.7	75	6	OFF	OFF
167	15	76	10.65	66	6	ON	ON
168	20	66	8.4	66	6	OFF	OFF
169	22	64	8	64	6	OFF	OFF
170	25	63	8.3	81	6	OFF	OFF
171	22	58	7.9	79	6	OFF	OFF
172	24	60	7.5	75	6	OFF	OFF
173	25	64	8.2	66	6	OFF	OFF
174	22	59	8.5	65	6	OFF	OFF
175	27	64	7.5	68	6	OFF	OFF
176	23	64	7.3	71	6	OFF	OFF

177	26	61	8.5	67	6	OFF	OFF
178	22	59	7.9	65	6	OFF	OFF
179	25	65	7.3	79	6	OFF	OFF
180	27	61	7.5	79	6	OFF	OFF
181	23	58	8.9	80	6	OFF	OFF
182	23	60	8.7	67	6	OFF	OFF
183	23	59	7.8	66	6	OFF	OFF
184	27	66	7.8	72	6	OFF	OFF
185	25	59	7.6	76	6	OFF	OFF
186	24	62	8.5	71	6	OFF	OFF
187	26	65	7.1	65	6	OFF	OFF
188	26	64	7.4	68	4	OFF	OFF
189	26	65	7.3	78	4	OFF	OFF
190	26	58	7.0	67	4	OFF	OFF
191	24	65	11	68	4	ON	ON
192	25	58	7.9	68	2	OFF	OFF
193	25	58	8.3	68	2	OFF	OFF
194	23	62	7.5	68	2	OFF	OFF
195	26	64	8.6	67	2	OFF	OFF
196	25	62	8.6	68	2	OFF	OFF
197	24	61	8.3	59	2	OFF	OFF
198	23	60	7.8	61	2	OFF	OFF
199	24	60	7.1	66	2	OFF	OFF
200	24	59	8.1	67	2	OFF	OFF

6.2 ANALYSIS OF DATA BY USER WITH HELP OF SERVER



WATER PUMP OFF motor ON ----- PH Value 17.57 17.57, W: 0, L: 0, T: 28, PH:17.3	03/03/22
WATER PUMP ON motor ON ----- PH Value 17.75 17.75, W: 0, L: 0, T: 28, PH:17.94	03/03/22
WATER PUMP OFF motor ON ----- PH Value 17.83 17.83, W: 0, L: 0, T: 28, PH:17.6	03/03/22
WATER PUMP ON motor ON ----- PH Value 17.72 17.72, W: 0, L: 0, T: 28, PH:17.72	03/03/22

```
close all;
clear all;
clc;
% % % % for i=1:10
% % % %     s_2016_out{i}='Disruption';
% % % % end
% % % % for i=11:20
% % % %     s_2016_out{i}='Normal';
% % % % end
%
s_2016_out={'Disruption','cra','cra','cra','cra','cra','cra','cra','cra','cra','cr
a','cra','cra','cra','cra','lof','lof','lof','lof','lof','lof','lof','lof','lof','
lof','lof','lof','lof','lof','lof','lof','lof','lop','lop','lop','lop'
,'lop','lop','lop','lop','lop','lop','lop','lop','lop','lop','por','por','por','po
r','por','por','por','por','por','por','por','por','por','por','sla','sla','sla','
sla','sla','sla','sla','sla','sla','sla','sla','sla'};
a=xlsread('sai_jayanth.xls');
for i=1:200
    s_2016_out{i}='OFF';
end
s_2016_out{25}='ON';
s_2016_out{110}='ON';
s_2016_out{167}='ON';
s_2016_out{191}='ON';
s_out=categorical(s_2016_out);

k=0;
for i=1:2:200
    k=k+1;
    signal_train(k)=[round(a(i,3:4))];
    out_train(k)=s_out(i);
end
    k=0;
for i=2:2:200
    k=k+1;
    signal_test(k)= [round(a(i,3:4))];
    out_test(k)=s_out(i);
end

XTrain = signal_train';
YTrain=out_train';
XTest=sigal_test';
YTest=out_test';

layers = [ ...
sequenceInputLayer(1)
bilstmLayer(100,'OutputMode','last')
fullyConnectedLayer(2)
softmaxLayer
classificationLayer
]

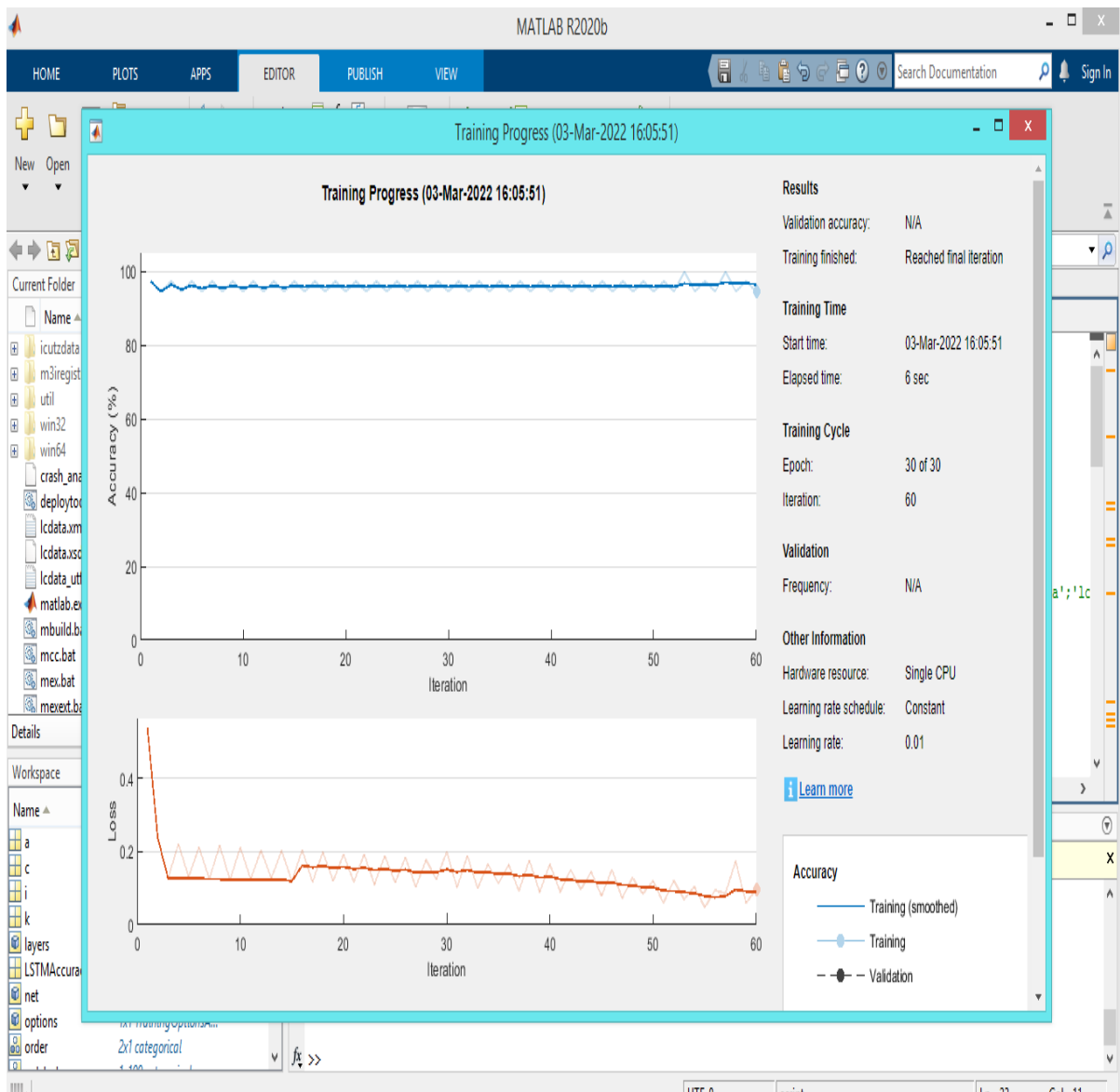
options = trainingOptions('adam', ...
'MaxEpochs',30, ...
'MiniBatchSize', 37, ...
'InitialLearnRate', 0.01, ...
'SequenceLength', 11, ...
```

```

'GradientThreshold', 1, ...
'ExecutionEnvironment','auto',...
'plots','training-progress', ...
'Verbose',false);
net = trainNetwork(XTrain,YTrain,layers,options);
trainPred = classify(net,XTrain,'SequenceLength',2);
LSTMAccuracy = sum(trainPred == YTrain)/numel(YTrain)*100
testPred = classify(net,XTest,'SequenceLength',2);
LSTMAccuracy = sum(testPred == YTest)/numel(YTest)*100
[c order]=confusionmat(YTest, testPred);
c

```

6.3 OUTPUT (MATLAB):



CONCLUSION

The study and implementation of one aquaponic system with IoT-assisted monitoring is done. In this project, concentration to be on the ratio of fish and plants and then determined whether the water recirculation can become balance for fish and plants or not. Since this ratio may change with different kinds of fish and plants, we utilize IoT techniques to record all experimental data. In the future, data can be learned and analyzed and then build one intelligent IoT automation aquaponic system.

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