A

PROJECT REPORT ON

"Development and Commercialization of IoT Based Vertical Farming"

SUBMITTED TO THE SHIVAJI UNIVERSITY, KOLHAPUR
IN THE PARTIAL FULFILMENT OF REQUIREMENTS
FOR THE AWARD OF THE DEGREE

OF

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

SUBMITTED BY

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UNDER THE GUIDENCE OF

Dr. K. R. Desai

DEPARTMENT OF

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

BHARATI VIDYAPEETH'S COLLEGE OF ENGINEERING, KOLHAPUR

NEAR CHITRANAGARI KOLHAPUR-416013

2023-2024

BHARATI VIDYAPEETH'S

COLLEGE OF ENGINEERING, KOLHAPUR

DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that, project report entitled ,***"Development and Commercialization of IoT Based Vertical Farming"*** submitted by **Miss. Rajashree Vasant Dhalgade, Miss. Aaditi Amar Gonugade and Miss. Chetana Mohan Malwadkar** is bonafide work carried out by them under the guidance of **Dr. K. R. Desai** and it is approved for partial fulfillment of the requirement of the Shivaji University, Kolhapur for the award of the Bachelor's Degree of Engineering in Electronics and Telecommunication Engineering

Dr. K. R. Desai	**Dr. K.R. Desai**	**Dr. V. R.Ghorpade.**
GUIDE	**H.O.D.**	**PRINCIPAL**

DATE: / / 2024

PLACE: - KOLHAPUR

BIG Electronics & Automation

1940, E-ward, Bus Route, Rajarampuri 12th Lane, Kolhapur, Maharashtra-416008.
Phone:-09420213538, 08956534547. Email: bigelectronicsautomation19@gmail.com.

CERTIFICATE

Date: 28/ 3/2024

To, H.O.D
E&TC Dept
Bharti Vidyapeeth's college of Engineering Kolhapur
Subject : completion of project

Respected Sir,

This is to certify that the students below are from Bharti Vidyapeeth's college of engineering, Kolhapur belonging to Electronics and Telecommunication Department has successfully completed the project " Development and commercialization of IoT based vertical farming"

As per our "Big electronics and Automation" hasd sponsored the project for the following student have been provided guidance by our doctors as per the requirement of the project.
Following are the students to whom the sponsorship letter has been given:

1. Malwadkar Chetana M.
2. Gonugade Aaditi A.
3. Dhalgade Rajshree V.

Big Electronics & Automation. Kolhapur

Big Electronics &Automation.

BIG Electronics & Automation

1940, E-ward, Bus Route, Rajarampuri 12th Lane, Kolhapur, Maharashtra-416008.
Phone:-09420213538, 08956534547. Email: bigelectronicsautomation19@gmail.com.

CERTIFICATE

Date 23|3|2024

To,

The HOD,

E&TC Dept,

B.V.C.O.E.K,

Subject: Approval for the sponsorship of the project "Development andcommercialization of IoT based vertical farming"

Respected sir ,

The project group of following students developed a project "Development andcommercialization of IoT based vertical farming" This project is beneficial for us. Hence we provide the sponsorship to this project under certain terms & conditions. These students are as follows

1. Malwadkar Chetana M.
2. Gonugade Aaditi A.
3. Dhalgade Rajshree V.

Kindly do the needful.

Thanking You

Yours truly,

BIG Electronics& Automation.

BIG Electronics & Automation

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3. Dhalgade Rajshree V.

Kindly do the needful.

Thanking You

Yours truly,

BIG Electronics & Automation
Kolhapur

BIG Electronics& Automation.

DECLARATION

We hereby declare that the project report entitled **“Development and Commercialization of IoT Based Vertical Farming”** is written and submitted by us under the guidance of **Dr. K. R. Desai** Bharati Vidyapeeth’s College of Engineering, Kolhapur. We understand that copying is liable to be punished in any by the university authorities deem fit. This work has been submitted by our sincere effort and has not been earlier submitted to any other institute of university for the award of degree.

Class: B.Tech. (Electronics & Telecommunication Engineering)

Place: Kolhapur

Date: / /2024

Yours Faithfully,

Miss. Rajashree Vasant Dhalgade

Miss. Aaditi Amar Gonugade

Miss. Chetana Mohan Malwadakar

B.Tech.(Electronics & Telecommunication Engineering)

ACKNOWLEDGEMENT

It gives us immense pleasure to express our sincere gratitude for constant help, encouragement and suggestions to us for our project report entitled **“Development and Commercialization of IoT Based Vertical Farming”** Under the guidance of **Dr. K. R. Desai** . We are thankful to him for guiding us through various difficulties and making it look easier.

We would also like to extend our sincere gratitude to Principal **Dr. V. R. Ghorpade** Bharati Vidyapeeth’s College of Engineering and **Dr. K. R. Desai** H.O.D., Electronics & Telecommunication Engineering for their whole support and guidance and their keen interest during the process of our project. Without the inspiration and encouragement the completion of project would be a difficult task.

Miss. Rajashree Vasant Dhalgade

Miss. Aaditi Amar Gonugade

Miss. Cheatana Mohan Malwadkar

. B.Tech. (Electronics & Telecommunication Engineering)

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LIST OF FIGURE

1.ABSTARCT:

The convergence of internet of things (IoT) technology with soil-based vertical farming presents a promising avenue for revolutionizing agriculture practices. This project delves into the integration of IoT systems within soil based vertical farming setups to optimize productivity resource management, and sustainability. IoT -enabled soil based vertical farming entails the deployment of sensors, and data analytics tools to monitor and regulate crucial environmental parameters within the farming infrastructure. These parameters include soil moisture content, humidity, nutrient levels, and light intensity. Real time data acquisition and analysis empower farmer to make data driven decisions, leading to improved crop yields and resource efficiency. Key components of IoT based vertical farming system includes automated irrigation systems, nutrient delivery mechanisms, climate control modules, and remote monitoring and control interfaces. These components work in tandem optimized growing conditions, fostering healthy plant growth while minimizing resource wastage. The adoption of IoT based soil based vertical farming holds significant potential for addressing global food security challenges, particularly in urban areas with limited arable land. By leveraging IoT technology, farmers can establish efficient and sustainable farming practices that mitigate environmental impacts of IoT based soil based vertical farming.

2.INTRODUCTION:

In recent years, the intersection of agriculture and technology has witnessed a remarkable evolution, with the emergence of innovative solutions aimed at addressing the challenges of modern food production. Among these advancements, IoT (Internet of Things) technology has significantly transformed traditional farming practices, paving the way for more efficient, sustainable, and scalable agricultural systems. In this context, vertical farming has emerged as a promising approach to cultivate crops in vertically stacked layers, optimizing space utilization and resource efficiency.

This project report presents an in-depth exploration and implementation of IoT-based soil-based vertical farming, an innovative solution that integrates IoT technology with traditional soil-based cultivation methods. The project aims to leverage IoT sensors, actuators, and automated systems to monitor and manage crucial parameters such as soil moisture, nutrient levels, temperature, and light intensity in a vertical farming setup. By collecting real-time data and employing advanced analytics, this approach enables farmers to make data-driven decisions, optimize growing conditions, and enhance crop yields.

The report encompasses the design, development, and evaluation of an IoT-based soil-based vertical farming system, highlighting the technical components, methodologies, and outcomes of the project. Additionally, it explores the potential benefits of this technology in terms of increased productivity, resource efficiency, and sustainability, along with its implications for future agricultural practices. Through this project, we aim to contribute to the ongoing discourse on IoT applications in agriculture and provide insights into the feasibility and effectiveness of IoT-based vertical farming systems.

In IoT-based soil-based vertical farming, a wide variety of crops can be cultivated depending on factors such as environmental conditions, space availability, market demand, and technological capabilities. Here are some examples of crops commonly grown in vertical farming systems:

1. Leafy greens: Lettuce, spinach, kale, arugula, and Swiss chard are popular choices for vertical farming due to their fast growth, high demand, and ability to thrive in controlled environments with consistent light and moisture levels.

2. Herbs: Basil, cilantro, parsley, mint, and oregano are well-suited for vertical farming systems, as they require relatively small spaces and can be harvested frequently.

3. Microgreens: Microgreens such as broccoli, radish, mustard, and amaranth are harvested at an early stage of growth and are prized for their intense flavors and nutritional content, making them ideal candidates for vertical farming.

4. Strawberries: Certain varieties of strawberries can be grown vertically, either in towers or hanging baskets, taking advantage of vertical space while providing a high-value crop.

5. Tomatoes: Compact varieties of tomatoes, such as cherry or grape tomatoes, can be grown vertically using trellises or other support structures, maximizing space utilization and facilitating easier harvesting.

6. Peppers: Bell peppers, chili peppers, and other varieties can be grown vertically in specialized systems, allowing for efficient use of space and optimal growing conditions.

7. Cucumbers: Compact cucumber varieties, such as mini or pickling cucumbers, can be grown vertically using trellises or vertical towers, reducing the footprint required for cultivation.

8. Strawberries: Certain varieties of strawberries can be grown vertically, either in towers or hanging baskets, taking advantage of vertical space while providing a high-value crop.

These are just a few examples, and the choice of crops may vary depending on the specific goals and constraints of the vertical farming operation. Additionally, advancements in vertical farming technology may enable the cultivation of a wider range of crops in the future, further expanding the possibilities for IoT-based soil-based vertical farming

3.LITERATURE REVIEW:

IoT (Internet of Things) based vertical farming is an innovative approach to agriculture that combines modern technology with sustainable farming practices. Vertical farming involves growing crops in stacked layers or vertical racks, often in controlled environments. IoT technologies can enhance the efficiency, productivity, and sustainability of vertical farming by providing real-time monitoring, automation, and data-driven decision-making.

➢ "IoT Based Smart Farming Application" (P.M. Dinesh et al., 2023):

This Research paper introduced the irrigation procedure is carried out automatically in the study of utilizing various sensors, which reduces manual work. It is suggested to utilize a sensor-based monitoring system for crop fields. It would entail gathering information on the soil moisture, humidity, and temperature. Automation of irrigation is possible by keeping an eye on all these variables.

➢ "IoT Based Mobile Application for Monitoring of Hydroponic Vertical Farming" (Gaganjot et al., 2022):

This paper presents the design of an IoT-based mobile application implemented on android studio for controlling and monitoring the growth of plants using Hydroponic vertical farming. The environmental conditions and nutritional parameters, such as temperature, humidity, Water level, etc., recorded from the sensors are sent to the Android Application .

➢ "Vertical Farming Using Internet of Things" (Karishma Moharatha et al., 2022):

This study focused on Vertical farming which is the practice of planting the plants in vertically stacked layers which optimize the land usage as it can be implemented in an indoor environment. The main idea of vertical farming is to use a controlledenvironment agriculture (CEA) technology, where all environmental factors can be controlled.

➢ "Vertical Farming To Sustain the Agriculture for Future Food Production and Supply" (T Naga et al., 2020):

The study explored Population of the entire world is growing very rapidly. By 2050 almost 70% of the available agricultural lands are reduced. India is one of the country having 2 ^ (n * d ^ - 1) largest population in the world. If India wants to feed remaining countries in the world it can but any country in the world is not sufficient to feed India. At any cost India have to be increase their food production by vertical farming to check the highly growing population, scarcity of water, change in climatic situation, scarcity of the skilled labour etc.

➢ "An Innovative Approach to Produce Forage Crops: Barley Fodder in Vertical Farming" (Volkan et al., 2020):

From this Paper we conclude that, cereal grain production in the vertical systems is not economically profitable today. considering remarkable increase in demands on forage crops, barley fodder production seems to have great potential for vertical farming systems. The benefits of the system such as less water use (about 90%), no herbicides, pesticides and fertilizer application relative to conventional production would be more pronounced for barley fodder in vertical system comparison to other conventional forage crops production systems. In this review, potential of barley fodder production in vertical farming system was discussed.

4. BLOCK DIAGRAM:

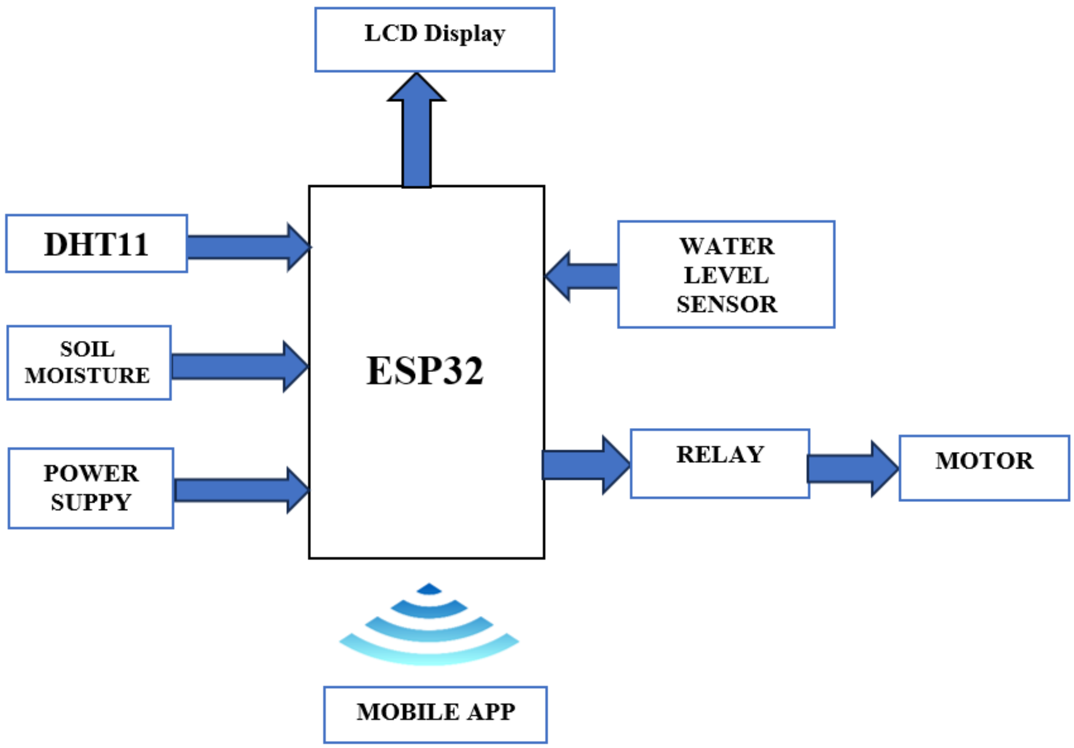

Fig1: Block diagram

This project consists of :

1. ESP32
2. SENSORS
3. MOTOR DRIVE
4. LCD DISPLAY

5.WORKING

As shown in figure, ESP32 is the microcontroller used here which is responsible for taking the data from the sensor and taking appropriate action. The DHT11 sensor can be used for Humidity measurement and Temperature measurement. The DHT11 sensor detects the humidity level of the environment in which they are placed. Humidity changes with temperature. If the temperature increases, so will the humidity. Then the water level sensor is used and informs whether the tank is empty or not.

LCD is used to print data on the display screen. And the Wi-Fi module is used to display information about the vertical farming unit in the application. When the tank is empty, the engine starts automatically.

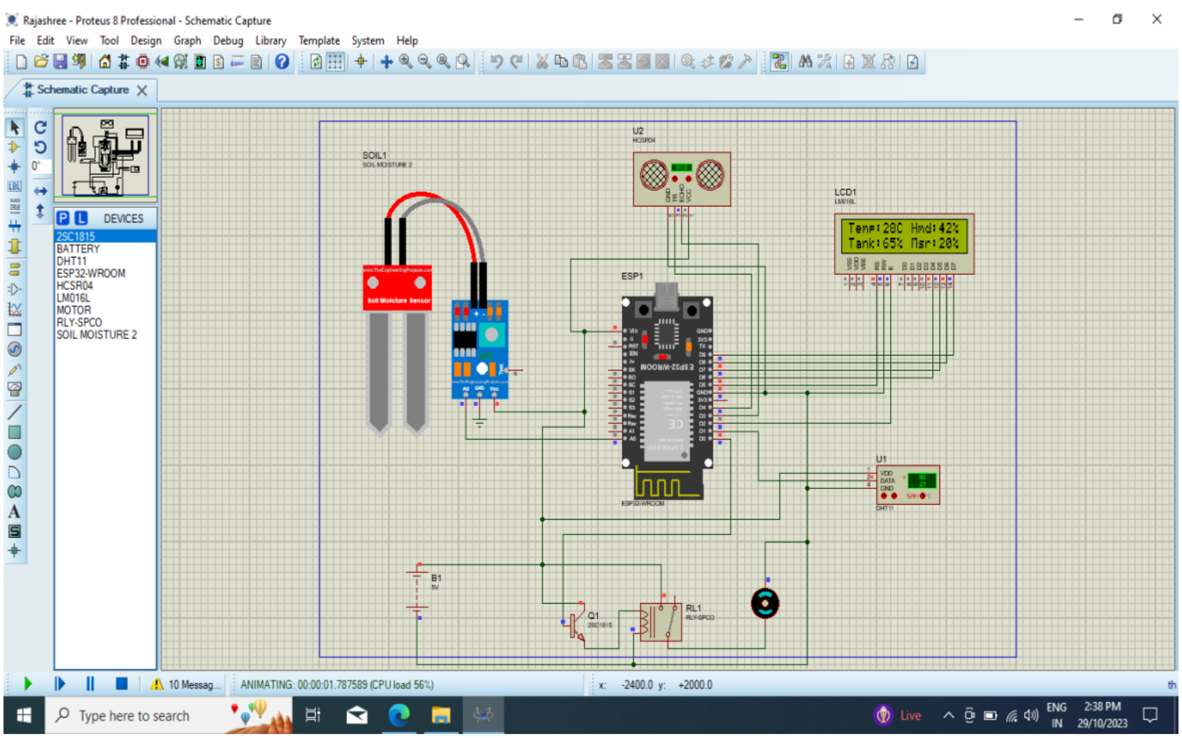

Fig2: Schematic Diagram

6.HARDWARE COMPONENTS AND SPECIFICATIONS

6.1ESP32:

ESP32 Pinout-

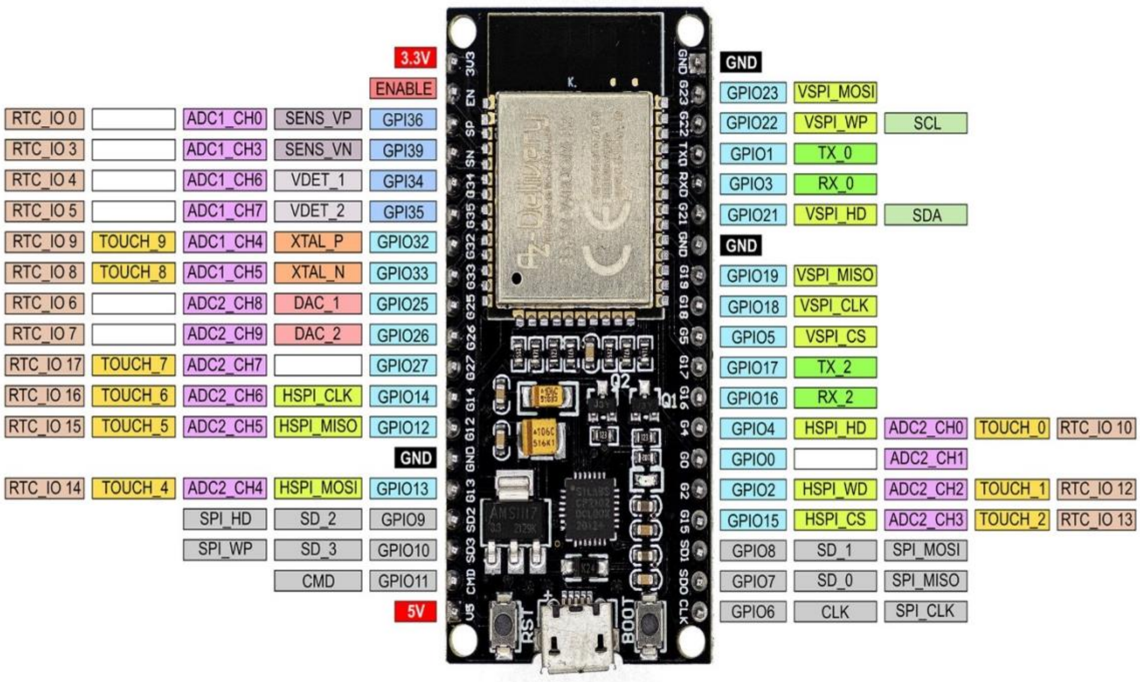

Fig3: ESP32

The ESP32 chip comes with 48 pins with multiple functions. Not all pins are exposed in all ESP32 development boards, and some pins cannot be used.

There are many questions on how to use the ESP32 GPIOs. What pins should you use? What pins should you avoid using in your projects? This post aims to be a simple and easy-to-follow reference guide for the ESP32 GPIOs.

ESP32 has a lot more features than ESP8266 and it is difficult to include all the specifications in this Getting Started with ESP32 guide. So, I made a list of some of the important specifications of ESP32 here. But for complete set of specifications, I strongly suggest you to refer to the Datasheet.

- Single or Dual-Core 32-bit LX6 Microprocessor with clock frequency up to 240 MHz.
- 520 KB of SRAM, 448 KB of ROM and 16 KB of RTC SRAM.
- Supports 802.11 b/g/n Wi-Fi connectivity with speeds up to 150 Mbps.
- Support for both Classic Bluetooth v4.2 and BLE specifications.
- 34 Programmable GPIOs.
- Up to 18 channels of 12-bit SAR ADC and 2 channels of 8-bit DAC
- Serial Connectivity include 4 x SPI, 2 x I^2C, 2 x I^2S, 3 x UART.
- Ethernet MAC for physical LAN Communication (requires external PHY).
- 1 Host controller for SD/SDIO/MMC and 1 Slave controller for SDIO/SPI.
- Motor PWM and up to 16-channels of LED PWM.
- Secure Boot and Flash Encryption.
- Cryptographic Hardware Acceleration for AES, Hash (SHA-2), RSA, ECC and RNG.

6.2MOTOR DRIVE:

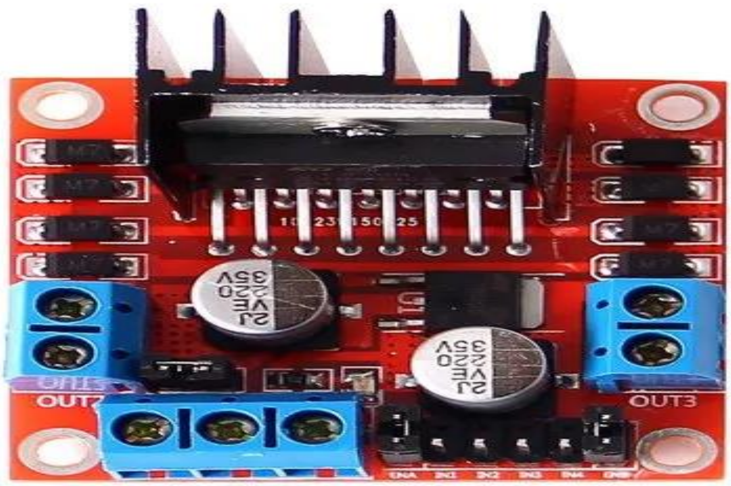

Fig4: Motor Drive

The L293D is a 16 pin IC, with eight pins, on each side, dedicated to the controlling of a motor. There are 2 INPUT pins, 2 OUTPUT pins and 1 ENABLE pin for each motor. L293D consist of two H-bridge. H-bridge is the simplest circuit for controlling a low current rated motor.

6.3 LCD SCREEN:

The project consists of a 5inch resistive touch with a high hard- ware resolution and HDMI Interface specially designed for the Raspberry Pi, shown in Fig 6. It has a resistive touch control It is compatible and has a direct connects with any revision of the existing Raspberry Pi. It provides drivers and the backlight can be turned on or off for the lower power consumption. According to the requirements of the project, a keyboard has been hardwired in this 5-inch dis- play for the vocally challenged to type their text in the screen

Fig5: LCD Display

Technical Specification

- Drivers provided (works with your own Raspbian/Ubuntu/Kali/Retropie)
- HDMI interface for displaying, no I/Os required (however, the touch panel still needs I/Os)
- High-quality immersion gold surface plating

6.4 SOIL MOISTURE SENSOR:

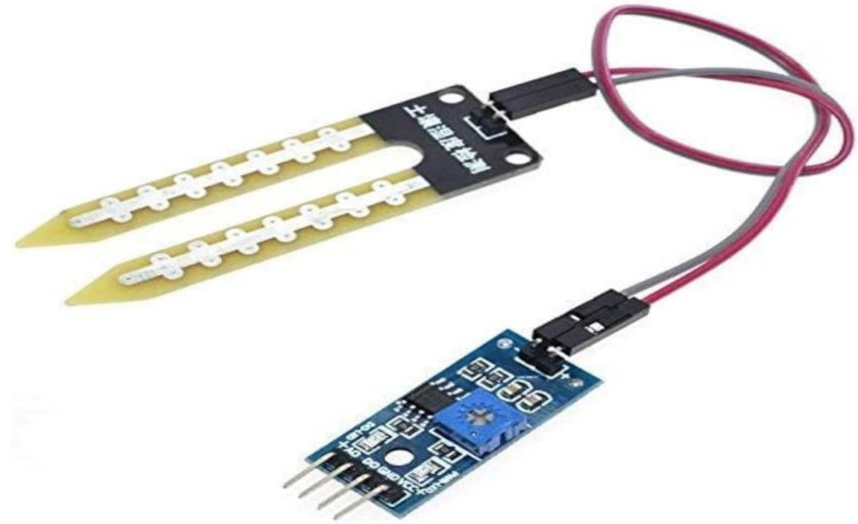

Fig6:Soil Moisture

The moisture of the soil plays an essential role in the irrigation field as well as in gardens for plants. As nutrients in the soil provide the food to the plants for their growth. Supplying water to the plants is also essential to change the temperature of the plants. The temperature of the plant can be changed with water using the method like transpiration. And plant root systems are also developed better when rising within moist soil. Extreme soil moisture levels can guide to anaerobic situations that can encourage the plant's growth as well as soil pathogens.

6.5 DHT11:

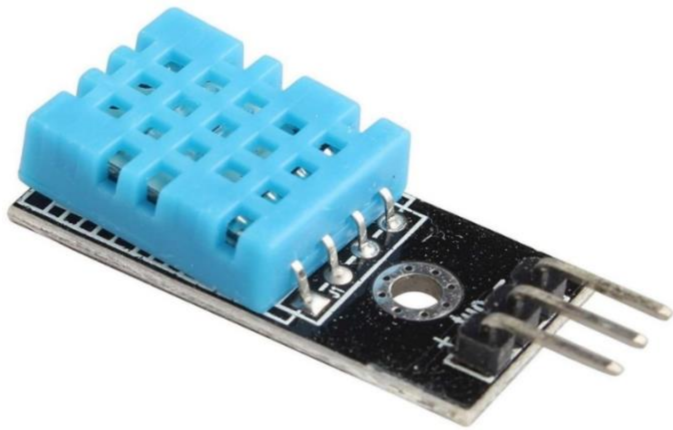

Fig.7: DHT11

The **DHT11** is a commonly used **Temperature and humidity sensor that** comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data.

- Operating Voltage: 3.5V to 5.5V
- Operating current: 0.3mA (measuring) 60uA (standby)
- Output: Serial data
- Temperature Range: 0°C to 50°C
- Humidity Range: 20% to 90%
- Resolution: Temperature and Humidity both are 16-bit
- Accuracy: ±1°C and ±1%

6.6 ULTRASONIC SENSOR:

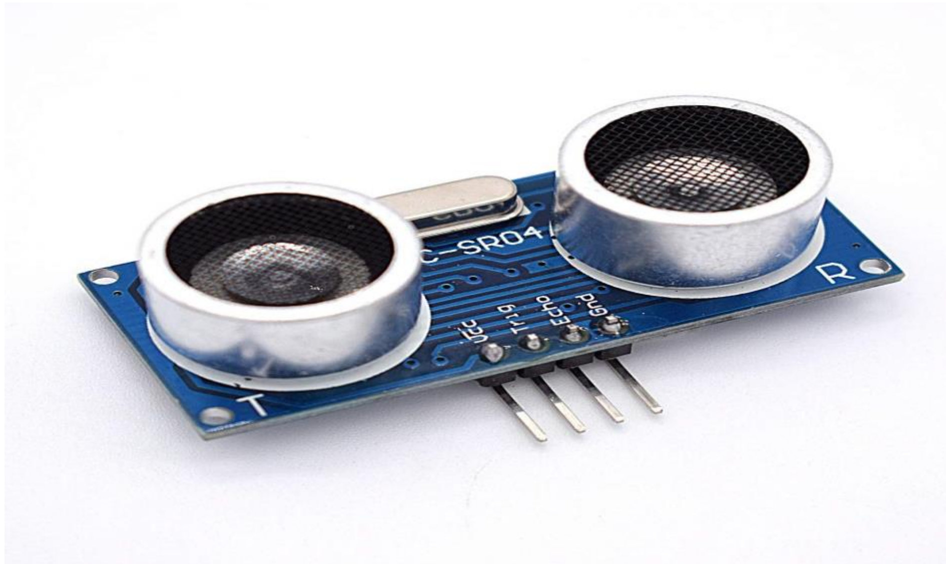

Fig.8: Ultrasonic Sensor

Ultrasonic sensors are in available for the past many decades and these devices continue to hold huge space in the sensing market because of their specifications, affordability, and flexibility The sensing range lies between 40 cm to 300 cm.

- The response time is between 50 milliseconds to 200 milliseconds.
- The Beam angle is around $5^{0.}$
- It operates within the voltage range of 20 VDC to 30 VDC
- Preciseness is ±5%
- The frequency of the ultrasound wave is 120 kHz
- Resolution is 1mm
- The voltage of sensor output is between 0 VDC – 10 VDC
- The ultrasonic sensor weight nearly 150 grams
- Ambient temperature is -25^0C to +70^0C
- The target dimensions to measure maximum distance is 5 cm × 5 cm

7.SOFTWARE CODE:

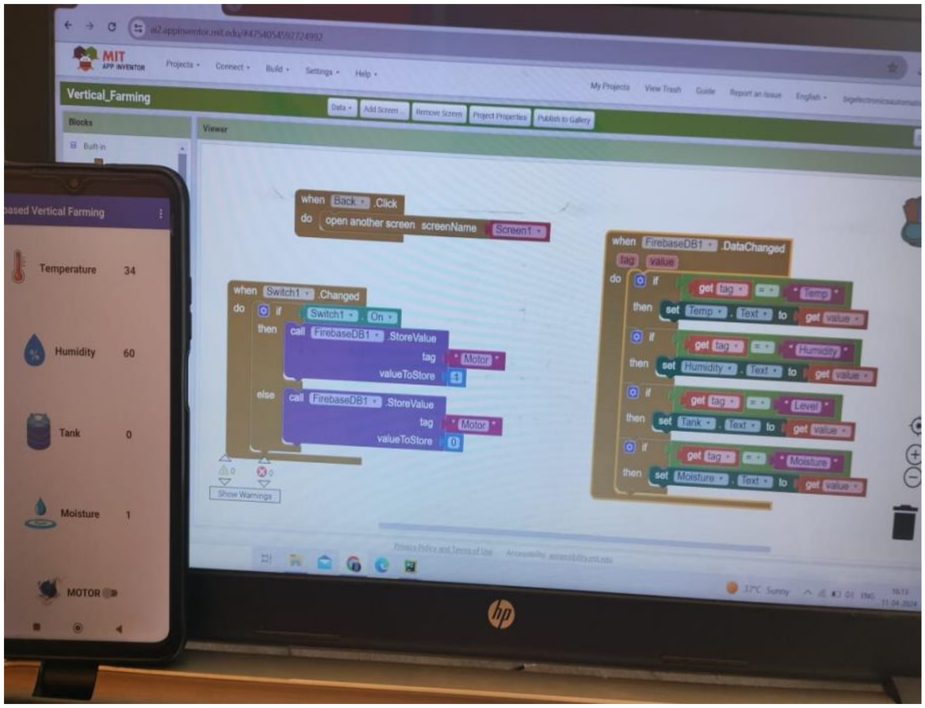

Fig.9:Software Code

MIT App Inventor (App Inventor or MIT AI2) is a high-level block-based visual programming language, originally built by Google and now maintained by the Massachusetts Institute of Technology. It allows newcomers to create computer applications for two operating systems: Android and iOS, which, as of 25 September 2023, is in beta testing. It is free and open-source released under dual licensing: a Creative Commons Attribution ShareAlike 3.0 Unported license and an Apache License 2.0 for the source code. Its target is primarily children and students studying computer programming, similar to Scratch.

8 .FARMING App:

A block diagram provides a visual representation of how different components in a system interact with each other. Let's break down the block diagram for the farming system you described:

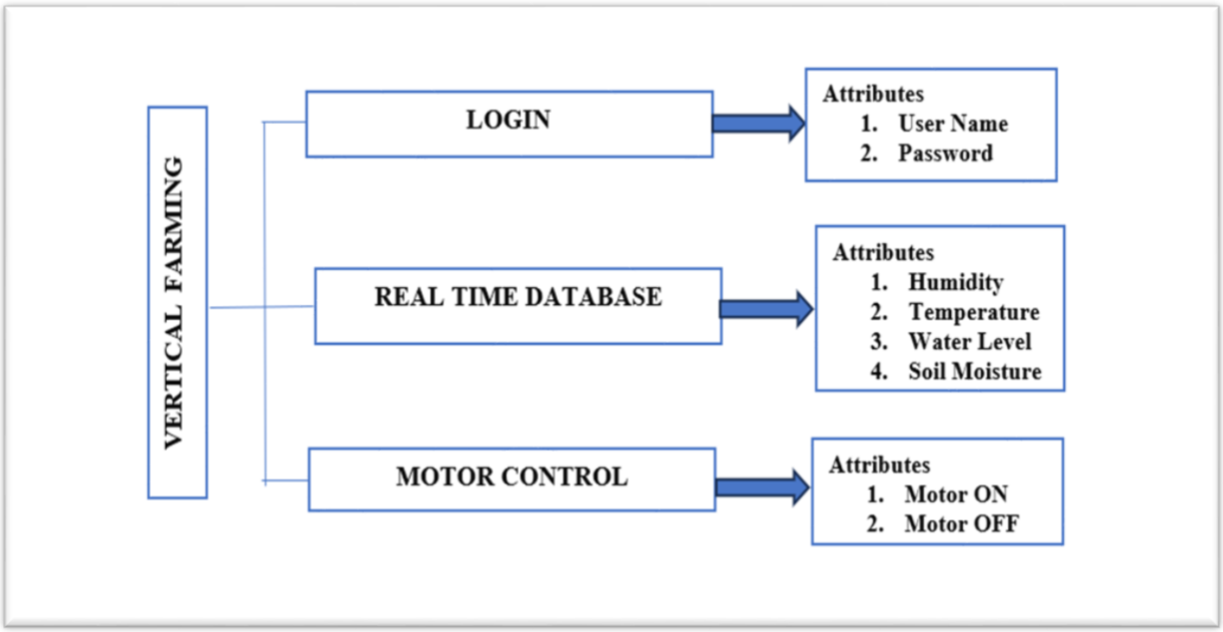

Fig.10: Application Block Diagram

8.1.FARMING LOGIN:

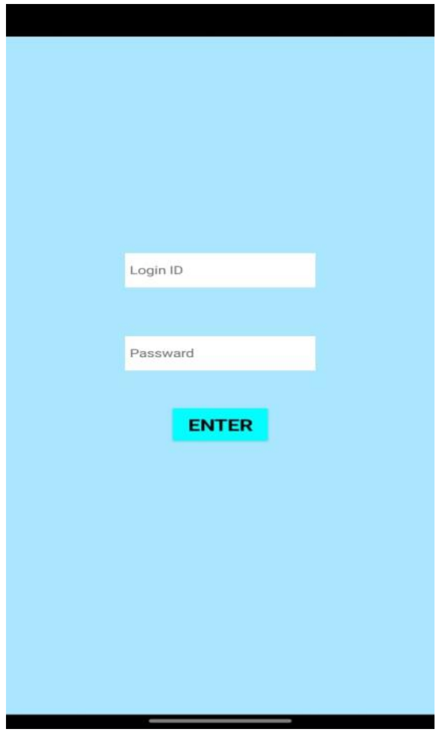

Fig.11:Login Page

Fig.12: App Details

This component handles user authentication.

It includes attributes such as:

- User Name
- Password

User Name: This is a unique identifier chosen by the user to access the system. It helps distinguish one user from another.

Password: This is a confidential string of characters chosen by the user to authenticate their identity. It ensures that only authorized users can access the system.

8.2.REAL-TIME DATABASE:

This component stores and manages real-time data from various sensors in the field.

Attributes include:

- Humidity
- Temperature
- Water Level
- Soil Moisture

Humidity: This attribute represents the moisture content in the air. Humidity levels can affect plant growth, pest activity, and overall environmental conditions in the farming area.

Temperature: This attribute indicates the ambient temperature in the farming environment. Temperature influences plant growth rates, crop development stages, and overall farm productivity.

Water Level: This attribute measures the level of water in a reservoir, tank, or irrigation system. Monitoring water levels is crucial for efficient irrigation management and preventing water-related issues such as over-watering or drought.

Soil Moisture: This attribute represents the amount of moisture present in the soil. Soil moisture levels impact plant growth, nutrient uptake, and irrigation scheduling. Monitoring soil moisture helps farmers optimize irrigation practices and ensure proper plant health.

8.3.MOTOR CONTROL:

This component controls the operation of motors in the farming setup.It can receive commands from authenticated users via the login component.

Attributes include:

- Motor ON
- Motor OFF

Motor ON: This attribute represents the command to activate or turn on the motor. When this command is received, the motor control component initiates the necessary actions to start the motor, which may involve providing power and control signals to the motor.

Motor OFF: This attribute represents the command to deactivate or turn off the motor. Upon receiving this command, the motor control component takes the necessary steps to stop the motor's operation, which may include cutting off power or interrupting control signals.

9 .PCB LAYOUT:

9.1 Introduction:

WHAT IS MEAN BY PCB (PRINTED CIRCUIT BOARD):

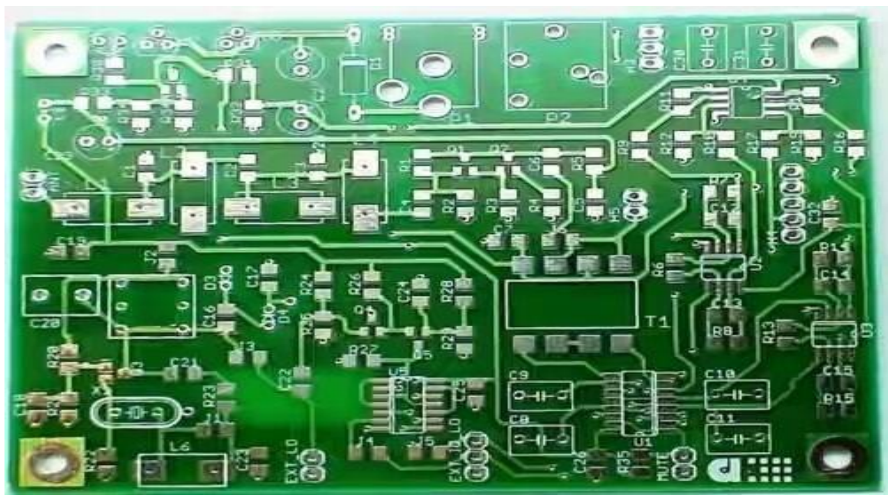

Fig13 PCB (Printed circuit Board)

A PCB is used to connect electronic components electrically. This is done by making conductive path ways for circuit connections by etching tracks from copper sheet laminated onto a nonconductive surface.

A PCB consists of a conducting layer that is made up of thin copper foil. The insulating layer die-electric is laminated together with epoxy resin pre preg. The most commonalty used PCB type is the FR-4. Boards may be single sided or double sided. Double sided PCB can be used to connect electronic components on both sides through through-hole plating. This is done by copper plating the walls of each hole so as to connect the conductive layers of the PCB.

Printed Circuit Boards are primarily an insulating material used as base, into which conductive strips are printed. The base material is generally fiberglass, and the conductive connections are generally copper and are made through an etching process. The main PCB board is called the mother board; the smaller attachment PCB boards are called daughter boards or daughter cards.

There are three basic varieties of printed circuit boards: -

1. Single sided PCB: Conductors on only one surface of a dielectric base
2. Double sided PCB: Conductors on both sides of a dielectrics base, usually the two layers are interconnected by plated-through-holes (pths).
3. Multi-layer: Conductors on 3 or more layers separated by dielectric material and the layer are interconnected by PTH or pads.

Multi-layer PCB boards are the norm for complex designs in particular those which have size constraints. The simplest of multi-layer boards is a 4-layer board which provides two internal power planes and two outer signal layers more complex multi-layer boards can reach up to 24 layers Some PCB material limit the number of layers, such as flexible PCB boards, but the advantages of using flex boards.

9.2 PCB Preparation:

Design Steps of PCB Fabrication:

1. Film Generation

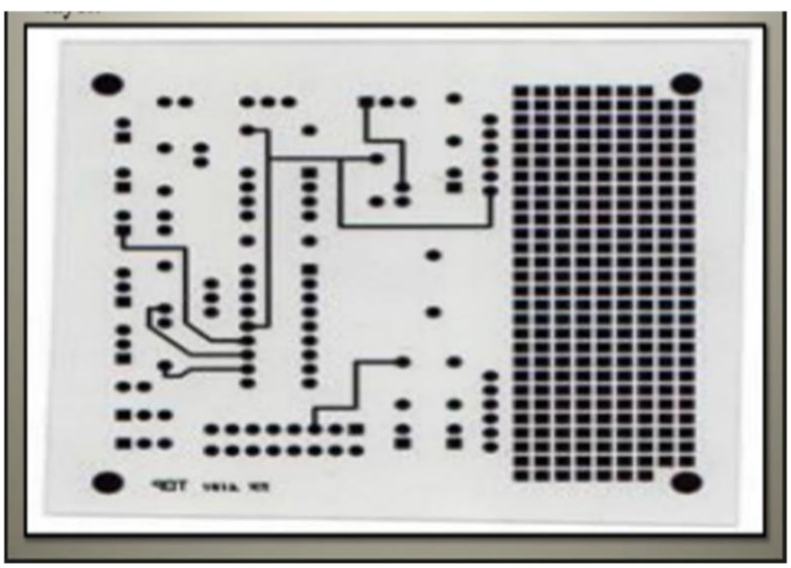

Fig.13: Film Generation

The film is generated from the design files (Gerber). Which are same to the manufacturing house. Once film is generated per layer.

A light sensitive film or photo image-able “resist” is then applied by heat and pressure to the metal surface of the core. The film is sensitive to ultraviolet light. You will find “yellow light” used in most image processing areas to prevent inadvertent exposure of the resist. The filters remove the wave length of light that would affect the resist coating.

In the Image expose panels are then exposed to a high intensity ultraviolet light source coming through the film. Clear areas allow light to pass through and polymerize (harden) the film resist thus creating an image of the circuit pattern-similar to a negative and a photograph.

1st taking the frame and applying the emulation to the frame, apply it to the 2side of frame, with no gap and bubble. Drying the emulation on both sides by using the hair drier. Acetates setting the frame.

Overhead go down then silk cover with thin foam; silk and covered with a glass foam then put glass on the black silk cover should put pressure on the acetates.

Emulation is exposed to ultraviolet light for 30 minutes. Then remove glass and foam and also glass and acetates, wash on both sides with pressure water is washed with water pressure casting. Only accept area is there and other area of emulation is removed because of water pressure. Now printed ready to do mesh in series. Silk drying on both sides for 10 minutes. Now silk is ready to print.

After fixing layout-films exactly on both sides of the laminated board the light sensitive cover is exposed by an ultraviolet light in double-sided drawer exposure unit with a vacuum system. After the exposure that part of the laminate, which is not protected by the layout film becomes etch- resistant (if we use negative film &negative photo resist). After properly aligning films on the photo resist laminated board, the board is exposed by a UV light on both sides in the UV exposure unit.

9.3 PCB Electroplating:

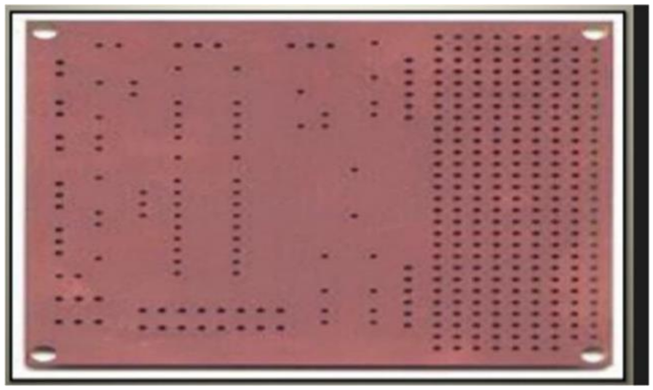

Fig.15: PCB Electroplating

When electroplating, copper is added to the PCB, so when electroplating is the expected method of producing through hole Conductivity.

This unit is used for making printed through hole (PTH) circuit boards, where connectivity from top to bottom layer can be made through holes. Here top and bottom layers are connected by depositing copper in holes of the board. This unit comprises all the tanks and equipment for degreasing, rinsing, catalyzing, activating, pickling and plating the drilled and cleaned boards. These processes of degreasing, rinsing, catalyzing,

activating, pickling is used for removing grease, oil, dirt, soot and other contaminants from surfaces. After thorough cleaning only copper is deposited.

9.3.1 Apply Image:

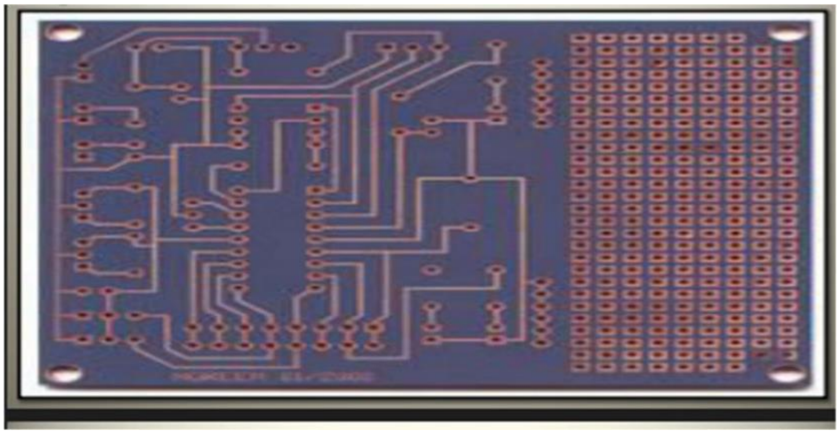

Fig.16: Apply Image

Apply photo sensitive material to develop selected area from panel. The frame is fixed with a hinge press (on the table) ex. For printing. Match the circuit board that is blank PCB and silk that is for printing.

Using ultraviolet painting printing is done. Ultraviolet paint spreads on the drawing by using spatula so tracing the paint is done.

After that drying may take up to 10 minutes by using oven. Apply photosensitive dry film to panel and use a light source and the film to expose the panels. Apply photo imageable mask on board surface to protect circuitry, prevent copper surface oxidation and act as solder resist.

9.4. Strip and Etch:

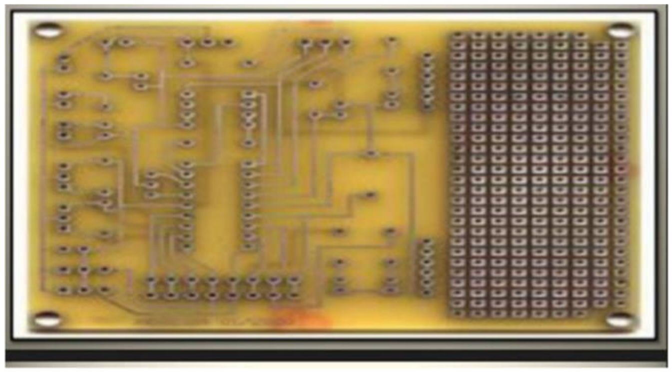

Fig.17: Strip and Etch

Remove dry film, and then etch exposed copper. Tin protects the copper circuitry from being etched. Remove the dry film, and then etch the exposed copper. The tin protects the copper circuitry from being etched away.

All pcbs are made by bonding layer of copper over the entire substrate, sometimes on both sides. Etching process has to be done to remove unnecessary copper after applying a temporary mask, leaving only the desired copper traces.

PCB cards exposed to ferric chloride or ammonia liquid and ammonia powder. Extra copper has been removing because of ferric chloride. Then wash PCB cards to remove ferric chloride that is thoroughly wash cards.

Wash PCB by brush to remove ink on it that is wash with caustic soda. Again, wash with water to remove soda. Then PCB dry thoroughly with dryer. Etch-resist solders masks, parts placement silkscreen legends, and even solder paste can apply to a PCB using silkscreen printing technology.

After treating the board with aqueous alkaline solution, the PCB is subjected in foam etching center by hanging it into a foaming fluid (usually acids) to etch out the copper from the part of the PCB not exposed to UV. The copper part of the PCB which is not exposed to UV gets softens and it is etched by acids. Now the board is ready with printed layout tracks, pads which are covered by photo resist.

In that process the UV non exposed copper is etched. Afterwards the etch resistant material over the tracks, pads of PCB are rinsed by means of a solvent attack.

9.5. Solder Mask:

Solder mask is usually the green coating on a PCB board which is designed to insulate and protect the underlying copper traces from environmental factors, and is also used to prevent bridging (shorting) traces during wave soldering.

Solder mask usually covers everything on the PCB board except for pads and vies, through it is good practice to cover via, especially if dealing with BGA components. This process is called tenting the vies.

Solder mask is shown on the CAD tool as a negative image. That is where there is solder mask “shown” is where there will be NO solder mask, in the masking conductive traces must match with the drawing, so the anti-solder spreads on the drawing by spatula.

Masking is done for the good protective coating this protects copper tracks and good presentation. After masking the PCB card drying may take up to 10 minutes. Apply a solder mask area to the entire board with the exception of solder pads.

Protect copper traces on outer layers from corrosion. Areas that shouldn’t may be covered with polymer resist solder mask coating. Designed to keep solder only in certain areas. Prevent solder from binding between conductors and thereby creating short circuits. Paste mask is similar to solder mask, except that it is used to create solder paste screens which can then be used to solder smds in a hot re-flow soldering process.

The bare copper PCB is silkscreened with a solder mask (usually green) (Sometimes the solder mask is applied by photo imaging or dry film) which is designed to insulate and protect the copper tracks and keep them from shorting together during the soldering process. The solder mask covers the whole board except solder able surfaces such as thru-hole and surface mount pads. The solder mask is then dried or cured. The PCB is tinned or plated, i.e., solder, silver or gold is applied to exposed pads. The PCB is silkscreened with component identification lettering (usually white). The silkscreen legend is dried or cured. Any final drilling of holes that are not to be plated through and any extra routing are now performed, and the laminate is cut into individual printed circuit boards.

9.6. Solder Coat:

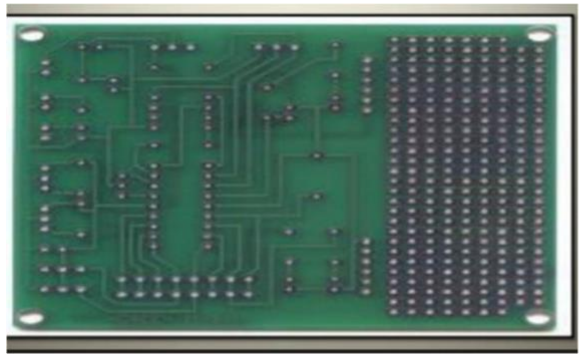

Fig.18: Solder Coat

Apply solder to pads by immersing into tank of solder. Hot air knives level the solder when removed from the tank. In order to ensure no shorting in the PCB due to formation of moisture, or due to spreading of solder lead, the complete boards except the pads are to be soldered masked. This is done in cad design tools and the photo film is generated in the photo plotter. Then the photo film is developed.

For the soldering (plating) the flux, solder, roll salt is to be used. In order to ensure no shorting in the PCB due to formation of moisture, or due to spreading of solder leads, the complete board except the pads is to be soldered masked. This is done in CAD design tools and the photo film is generated in the photo plotter. Then the photo film is developed.

9.7 PCB layout:

The first step in power supply is to choose the type of power supply you wish to use you're your device. Unregulated power supplies are a down-and-dirty option for converting AC power from a wall outlet to a DC voltage. The output from these supplies will contain a ripple waveform as the output is not smoothed with a regulator. Modern applications use a regulated power supply, where this ripple is minimized.

There are two principal options for regulating DC output from power supplies: using a linear regulator or a switching regulator, which is sometimes called a switch-mode power supply. These types of power supplies pass the DC output from a full wave rectifier to a regulation circuit, which smooths the ripple waveform that is superimposed on the desired DC output. These regulators can also be used to directly regulate a DC power source like a battery. Linear regulators have very low noise, but they tend to be bulky due to the use of heatsinks or other active cooling measures required for thermal management. The significant heat dissipation in these power supplies is responsible for their low efficiency.

1. DRAW BOARD OUTLINE

1. Initially the work area is empty. Before placing the components, a border must be drawn.

   Use 2D graphics box mode button to draw the border.
2. Choose yellow color for board edge from setting tool at the bottom of main window.
3. Click in the workspace, hold down the left button, draw a rectangle of appropriate size and release the button.
4. Go in track mode (E) and select width 30th, OK.

2. CHOOSE LAYERS

1. For a single sided board, you probably want only the bottom layer, for double sided board top and bottom layers are required and for 4-layer board you want these plus power and ground plane layers.
2. Go in design rule manager.
3. Select net classes, select bottom copper.

3. PLACE COMPONENTS

1. A tool is used for automatic placing of all the components. Right click on the components to see more options like rotate.
2. This can be done manually as well.

4. ROUTING

1. For automatic routing go in auto router.
2. Click the strategies button, set the routing strategy open the dialogue box. Select single strategy, single layer width T30.

9.8. LAYOUT:

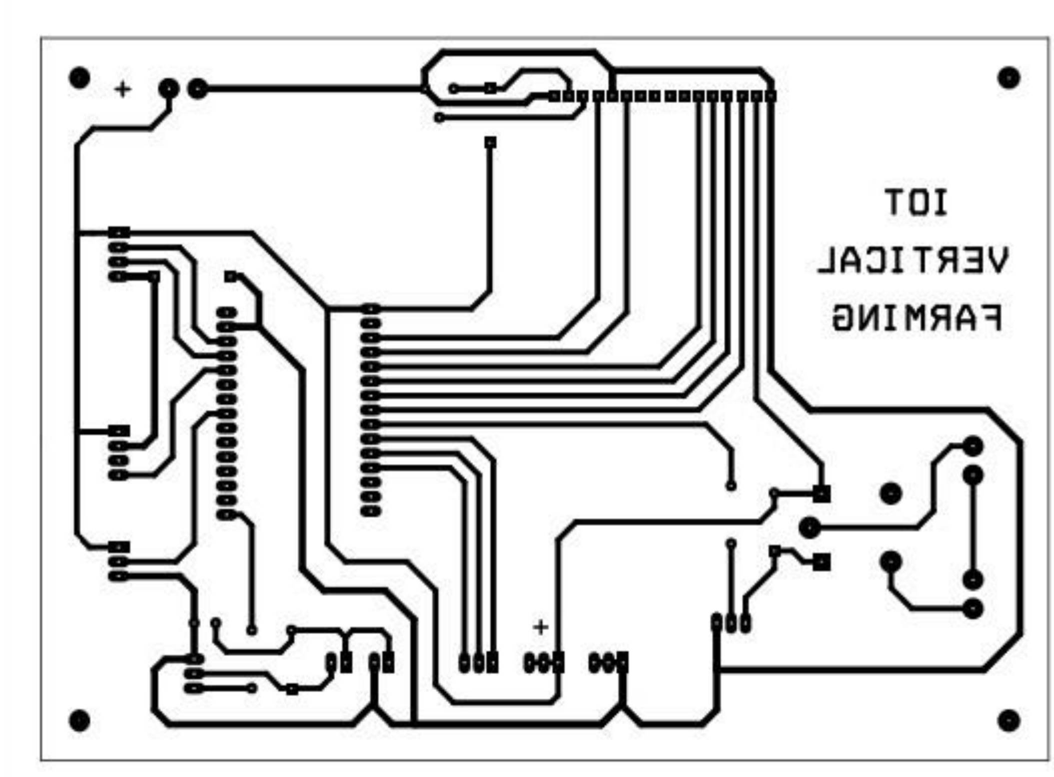

Fig.19:Bottom and Top PCB Layout

9.9. PCB DRILLING:

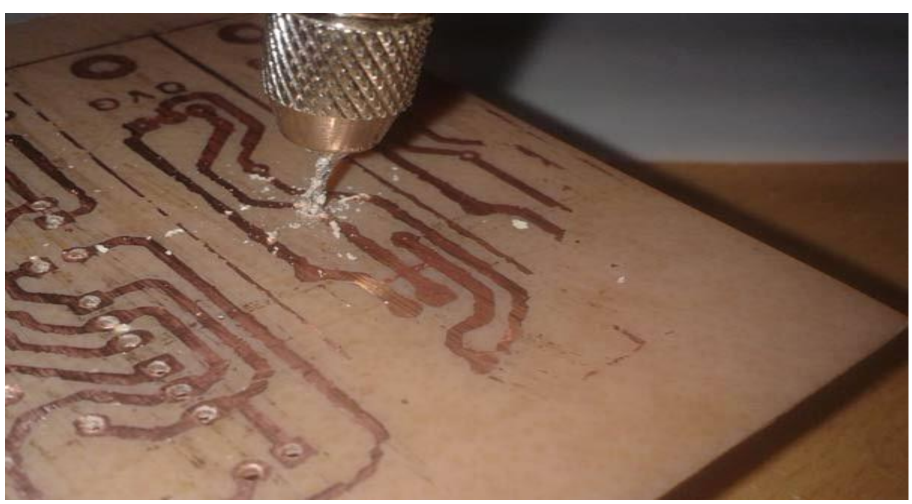

Fig.20: PCB DRILLING

Holes through PCB are typically drilled with small diameter drill made of solid coated tungsten carbide. Coated tungsten carbide is recommended since many board materials are very abrasive and drilling must be at high rpm and high feed to be cost effective.

Drill bits must also remain sharp so as not to mar or tear the traces. Drilling with highspeed steel is simply not feasible since the drill bits will dull quickly and thus tear the copper and ruin the boards. The drilling is performed by automated drilling machines with placement controlled by a drill tape or drill file.

These computer-generated files are also called as numerically controlled drill (NCD) files. The drill file describes the location and size of drilled hole. Holes may be made conductive by electroplating or inserting metal eyelets (hollow), to electrically and thermally connect board layers. Some conductive holes are intended for the insertion of through-hole-component leads.
Others typically smaller and used to connect board layers are called vias.

Fig.21: PCB Etching

The simplest method used for small scale production and often by hobbyists is immersion etching in which the board is submerged in etching solution such as ferric chloride.

Compared with methods used for mass production, the etching time is long. Heat and agitation can be applied to the bath to speed up the etching rate.

In bubble etching, air is passed through the etchant bath to agitate the solution and speed up etching. Splash etching uses a motor-driven paddle to splashboards with etchant; the process has become commercially obsolete since it is not as fast as spray etching.

In spray etching, the etchant solution is distributed over the boards by nozzles and recirculated by pumps. Adjustment of the nozzle pattern, flow rate, temperature and etchant composition give predictable control of etching rates and high production rates.

As more copper is consumed from the boards, the etchant becomes saturated and less effective; different etchants have different capacities for copper with some as high as 150 grams of copper per liter of solution.

Where metallic plating is used as resist, it can “overhang” which can cause short circuits between adjacent traces when closely spaced. Overhang can be removed by wire-brushing the board after etching.

9.10 PCB MOUNTING:

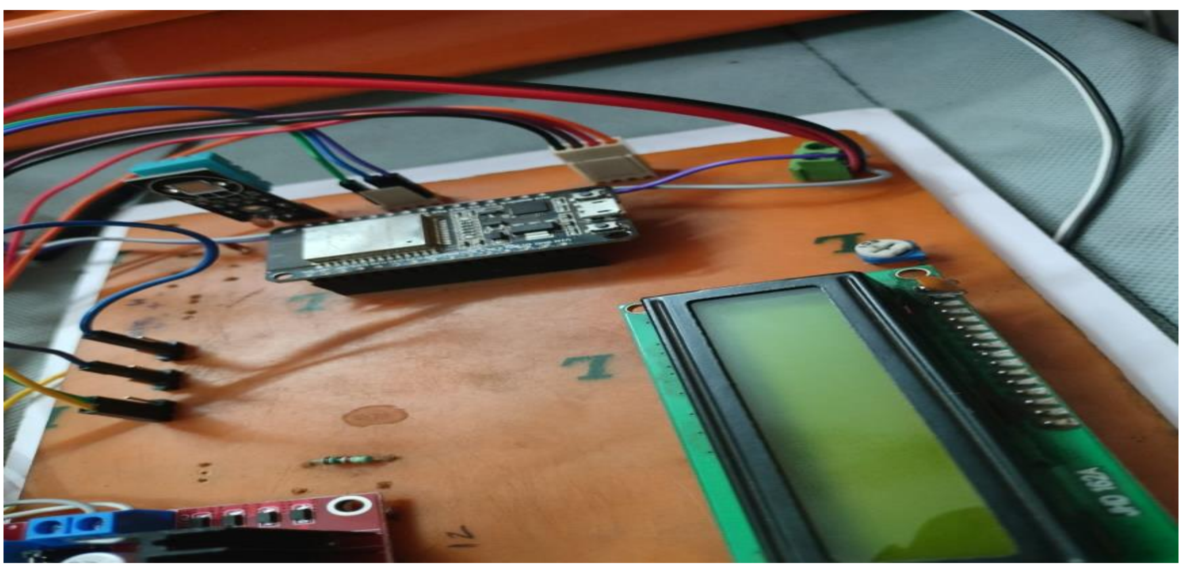

Fig.22:PCB Mounting

Printed circuit board (PCB) is a base of any electronics/electrical equipment. A PCB provides the connectivity to the electronic components such as LDR, capacitor, resistor, diodes, transistor, ics, led, buzzer etc. To form a complete electronic circuit. In the present scenario, the existence of electronic equipment's cannot be imagined without a PCB.

The pcbs are not only providing the connectivity among the electronic components but also reduces the size and increases the efficiency of the electronic equipment. Broadly the pcbs may be divided in two categories i.e., single layer pcbs and multilayer pcbs.

One can easily find the contribution of electronic industries in each and every field of our daily life i.e., entertainment, communication, education, R&D, public services, defense, transport, agriculture, health care services etc. With the growing demand of electronic equipment's/appliances in every sphere of human beings the electronic industry is growing up with a very fast rate.

Similarly, the demand of micro servicing industries such as assembling/mounting of electronic components on pcbs to meet the requirement of the small/medium/large scale electronic industries is also increasing.

9.11 SOLDERING:

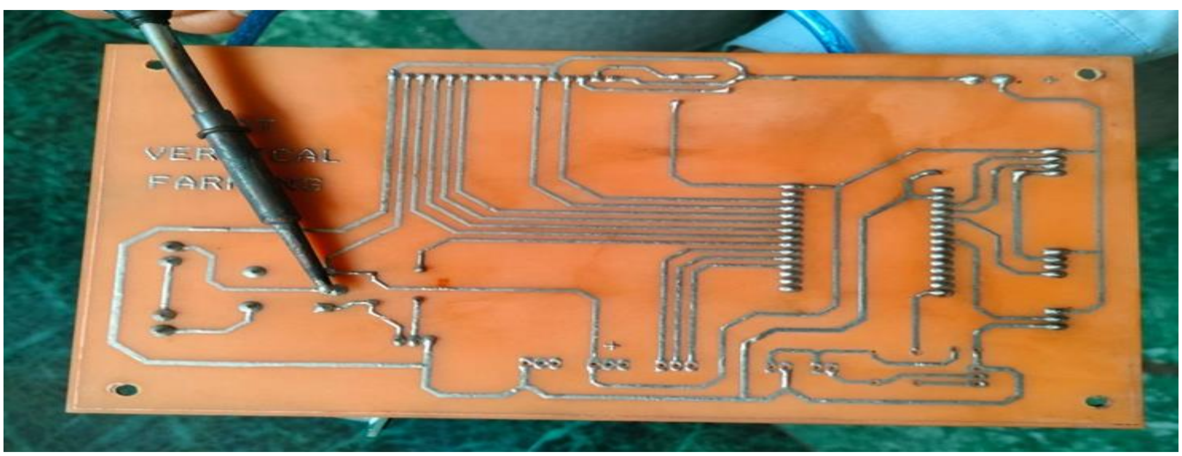

Fig.22: PCB Soldering

Soldering is a process in which two or more metal items are joined together by melting and flowing a filler metal (solder) into the joint, the filler metal having a lower melting point than the adjoining metal. Soldering differs from welding in that soldering does not involve melting the work pieces.

In brazing, the filler metal melts at a higher temperature, but the work piece metal does not melt. In the past, nearly all solders contained lead but environmental concerns have increasingly detected use of lead-free alloys for electronics and plumbing purposes. Soldering filler materials are available in many different alloys for differing applications. In electronics assembly, the eutectic alloy of 63% tin and 37% lead (or 60/40, which is almost identical in melting point) has been the alloy of choice.

Other alloys are used for plumbing, mechanical assembly and other applications. Some examples of soft-solder are tin-lead for general purposes, tin-zinc for joining aluminum, leadsilver for strength at higher than room temperature, cadmium-silver for strength at high temperatures, zinc-aluminum for aluminum and corrosion resistance and tin-bismuth for electronic.

10. Final setup:

Fig.23: Final setup

11. CONCLUSION:

In conclusion, the project on the development and commercialization of IoT-based vertical farming represents a significant opportunity to revolutionize modern agriculture. By integrating IoT technology into vertical farming systems, we can achieve efficient resource management, enhance crop productivity and promote sustainable food production practices.

Through this project, we have demonstrated the feasibility and potential of IoT-enabled vertical farming solutions in addressing key challenges faced by traditional farming methods, such as limited land availability, water scarcity and climate variability. By leveraging real-time data insights, remote monitoring, and precise control capabilities, our vertical farming system offers farmers unprecedented levels of control over their operations, leading to improved crop yields, reduced resource consumption and minimized environmental impact.

The commercialization aspect of the project opens up new avenues for market penetration and revenue generation. By offering turnkey solutions, consulting services, and innovative products tailored to the needs of farmers, urban communities and commercial enterprises, we can capitalize on the growing demand for fresh, locally grown produce and sustainable agricultural practices.

12.FUTURE SCOPE:

The future scope for the project on the development and commercialization of IoT-based vertical farming is vast and holds significant potential for further innovation and impact.

Here are some key areas of future exploration and expansion:

1. **Advanced Sensor Technologies:** Continued advancements in sensor technologies will enable the development of more sophisticated IoT systems for vertical farming. Integrating multispectral imaging, hyperspectral imaging, and advanced spectroscopy techniques can provide deeper insights into plant health, nutrient levels, and disease detection.
2. **AI and Machine Learning Integration:** By incorporating artificial intelligence (AI) and machine learning algorithms into IoT platforms, vertical farming systems can become more intelligent and adaptive. AI can analyze vast amounts of data to optimize growing conditions, predict crop yields, and automate decision-making processes for enhanced productivity and resource efficiency.
3. **Vertical Integration and Smart Supply Chains:** Vertical farming systems can be integrated with smart supply chain solutions to optimize logistics, distribution, and inventory management. IoT-enabled sensors can track the quality and freshness of produce throughout the supply chain, ensuring timely delivery and minimizing waste.

13.ADVANTAGES:

- Resource Efficiency
- Increased Crop Yields
- Local Food Production
- Sustainability
- Scalability and Adaptability

14. REFFERENCES:

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- *Authors*: Sushma D. Patil, Prachi D. Vairagade, Jayant Kulkarni

- *Published in*: International Research Journal of Engineering and Technology (IRJET), Volume: 06 Issue: 05, May 2019

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- Authors: Abdulelah Alaboudi, et al.

- Published in: Sensors, 2019.

- Link: [IoT Applications in Vertical Farming: Technologies and Challenges](https://www.mdpi.com/1424-8220/19/21/4827)

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- Link: [IEEE Xplore](https://ieeexplore.ieee.org/document/8054844)

6. *"Smart Agriculture: IoT Based Smart Sensors Agriculture Stick for Vertical Farming"*

- Authors: S. S. Gawade, et al.

- Published in: 2018 International Conference on Computing, Power and Communication Technologies (GUCON), 2018.

- Link: [IEEE Xplore](https://ieeexplore.ieee.org/document/8635337)

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- Published in: Sensors, 2021.

- Link: [IoT-Based Vertical Farming System for Indoor Vegetable Cultivation](https://www.mdpi.com/1424-8220/21/9/3075)

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