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Department of Electronics and Telecommunication

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Project Group ID - 11

Hydroponics Based Precision Farming with Feature Optimization Approach

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Overview :

Overview :

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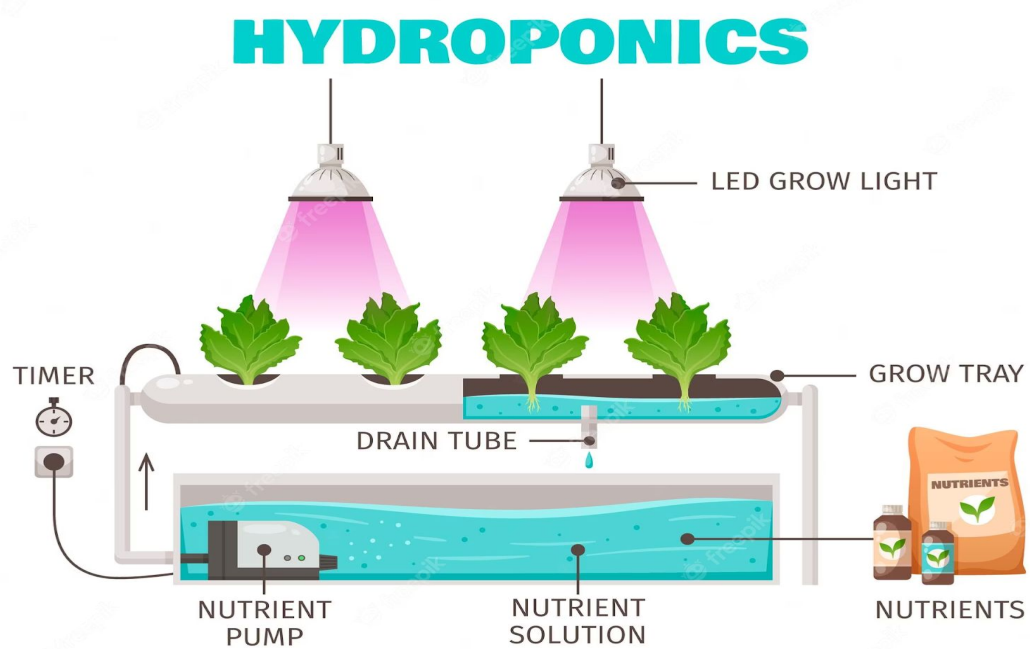
1.1. What is hydroponics?

- Hydroponics is a modern agricultural method that involves **growing plants without soil,** using nutrient-rich water solutions to supply essential minerals directly to the plant roots.

- In hydroponic systems, plants are typically **grown in a controlled environment,** such as greenhouses or indoor setups, where factors like temperature, light, and humidity can be carefully regulated to maximize plant growth and productivity.



1.2. What are its advantages?

- Hydroponics Saves Space.
- Hydroponic Systems Save Water.
- Hydroponic Systems Use Less Chemicals.
- More Growth in Hydroponic Systems.
- More Control of Nutrients.
- Indoor Environment.
- Hydroponics Produces Healthier Plants and Bigger Yields.
- No Soil Erosion or Weeds.

1.3. Current Limitations with Hydroponics

- The **initial setup cost** of hydroponic systems can be relatively high, including investments in equipment, infrastructure, and technology, making it less accessible for small-scale farmers.

- In hydroponics, precise control over nutrient levels can be challenging, leading to the **risk of overfeeding or underfeeding plants**, potentially impacting their health and productivity.

- **Inadequate monitoring of air supply** in closed hydroponic environments may lead to oxygen deficiencies, affecting root health and ultimately causing plant mortality.

- Hydroponic farming demands a **deeper understanding of nutrient management, and system operation**, requiring farmers to possess specialized knowledge and expertise, which may be a barrier for newcomers to the technique.

1.4. Why automation and advancement is needed in it

- **Rising world population** demands increased agricultural productivity, which can be achieved through automation to meet growing food demands efficiently.

- **Sudden climate change** poses unpredictable challenges for farmers, necessitating automation to adapt quickly and ensure stable crop yields.

- Implementing agricultural automation can **decrease pesticide usage** by employing precision techniques, and promoting sustainable farming practices.

- Automation enables the **creation of optimal growing conditions regardless of time and location,** maximizing crop output and reducing dependence on specific climates.

- By automating tasks, agriculture requires **minimum labor efforts**, freeing up human resources for higher-value activities and improving overall productivity.

1.5. Features added due to Automation

- Automation systems can **maintain precise and consistent** environmental **conditions**, such as temperature, humidity, and nutrient levels. This consistency is essential for achieving optimal plant growth.

- Automated systems can be programmed to **optimize energy usage**, such as adjusting lighting and ventilation based on plant needs and environmental conditions. This helps reduce energy consumption and operational costs

- Automation can **detect early signs** of plant stress or **disease**, For example, automated sensors can detect changes in plant color or growth patterns that may indicate problems.

- Automation systems are **scalable**, making it easier to expand hydroponic operations as needed. This scalability is especially important for commercial growers looking to increase production.

1.6. Objectives

- To **Design a hydroponics system** with low initial setup cost and achieves significant yield.
- To **optimize power utilization** using time slotting.
- To **reduce water consumption by 70-80%** through the efficient closed-loop water circulation system.
- To **incorporate Cloud and iot** to process real time data and allow remote access.
- **Develop a website and mobile application** to support remote control, monitoring, and alert functionality.
- To **develop/optimize** various machine learning and other **algorithms** for this system.
- To **design** Uninterrupted Power Supply (**UPS**) for the system.
- To **Automate Monitoring** Process Using image analysis.

1.7. Methodology

- **Conduct research on optimizing** the effects of TDS, air pump duration UV light duration on plant growth with various control scheme as per given data with appropriate algorithms.

- **Predict water** tank **refill** time using humidity and temperature with given data with appropriate algorithms.

- Design air pump, water pump, fan **driver circuits** for effective and safe use of electronics resources.

- Implement the LDR sensor for **fault detection** of UV lights**.**

- Incorporate **Sensors and Actuators** to automate the watering process if sensors value falls below a predetermined threshold.

- Incorporate **schedule operations,** allowing for continued functionality even after lights shut down.

Methodology

- Implementation of **Image processing and analysis** to support monitoring of Plant growth.
- Integration of **cloud and Iot technology** for <u>data processing and enabling for future advancements</u>.
- Use of **M2M techniques** for <u>efficient data flow</u> of system.
- Power Optimization Using **Time slotting.**
- UPS using **mosfet as a diode controlled device** and NOT logic.
- Real-Time Clock (**RTC**) to **schedule** operations.

2.1. Research literature survey summary

- New technologies are being researched and improvements are being done in areas like nutrients composition, supply, medium as well as effect of light, temperature, humidity and EC/TDS and pH conditions as this have show to have a linear relation with plant growth.
- Althogt introduction of automation and and AI in hydroponics has been stated for a long long time, most of it has been for simulated environment, either physical or virtual through matlab.
- Even model building of Ai research work exists most of them are either for simulated environment, and built using data form real, life but their effectiveness in actual farming has not been shown.
- As most work in his domain have not utilised/shown research techniques that will turn this technology(introction of ai and automation) into a feasible product , showing efficiency, and effectivity which we intend to do rather than only focuning of plant growth.

2.2. Market literature survey summary

1. The Hydroponics Market size is expected to grow from USD 4.69 billion in 2023 to USD 6.83 billion by 2028, at a CAGR of 7.80% during the forecast period (2023-2028).North America Dominates the Market, while asia pacific is fastest growing in market [1].

2. It is set to grow rapidly on account of the surging implementation of this agricultural method in Australia, Japan, India, and China [2].

3. The global market is highly fragmented with the presence of multiple companies. Most of them are focusing on R&D activities to come up with state-of-the-art techniques for surging sustainability and saving costs [3].

4. March 2021: The state government of Ahmedabad announced its plan to accelerate hydroponic farming in cities to encourage households to grow vegetables in their homes. The agriculture department staff will provide hands-on training to residents with DIY videos [4].

3. Specification

3.1 General specifications

● Temperature range: 0-50 degree Celsius

● Humidity range: 20% to 90%

● Accuracy: ±2°C and ±5%

● Bluetooth protocol: Bluetooth v2.0+ & EDR

● Frequency: 2.4GHz ISM band

● Core RAM size: 2K

3.2 External system specification

3.2.1 UV light

- Type: USB
- Adjustable intensity
- Adjustable color (red, blue, violet)
- Voltage consumption at Max. Brightness: 5V, DC
- Current consumption at Max. Brightness: 1.45A

3.2.2 Air pump

- Type: USB
- Voltage consumption: 5 – 5.1V, DC
- Current consumption: 0.15A

3.2.3 Fan

- Type: USB
- Voltage consumption at maximum speed: 5V, DC
- Current consumption at maximum speed: 0.91A

3.2.4 Water pump

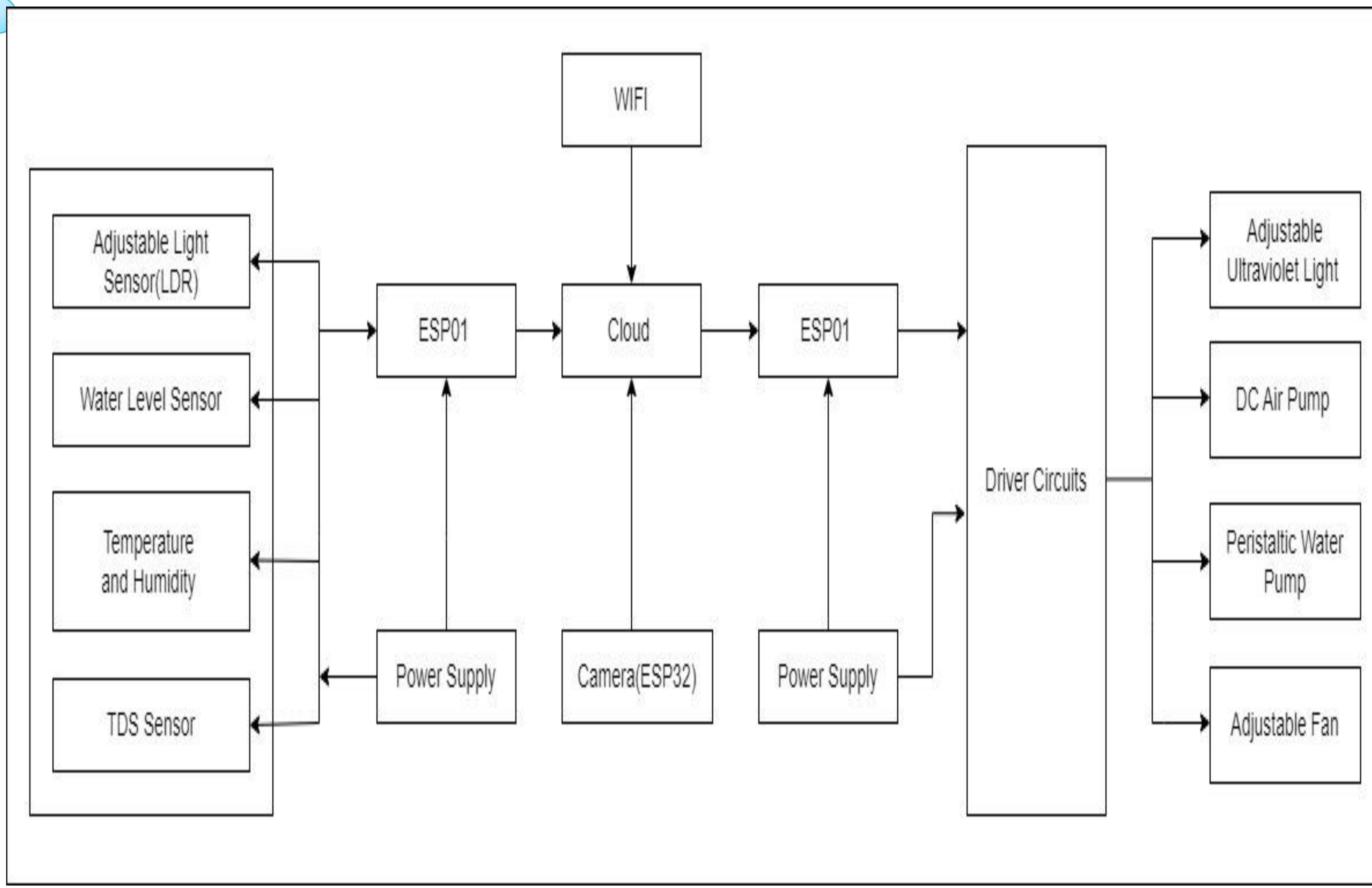
- Voltage consumption: 5V
- Current consumption: 0.31A

Thus, the whole project runs on 5V DC USB power supply, and at Max. load, the current consumption is 3.03A.

3.3 Technical Specifications

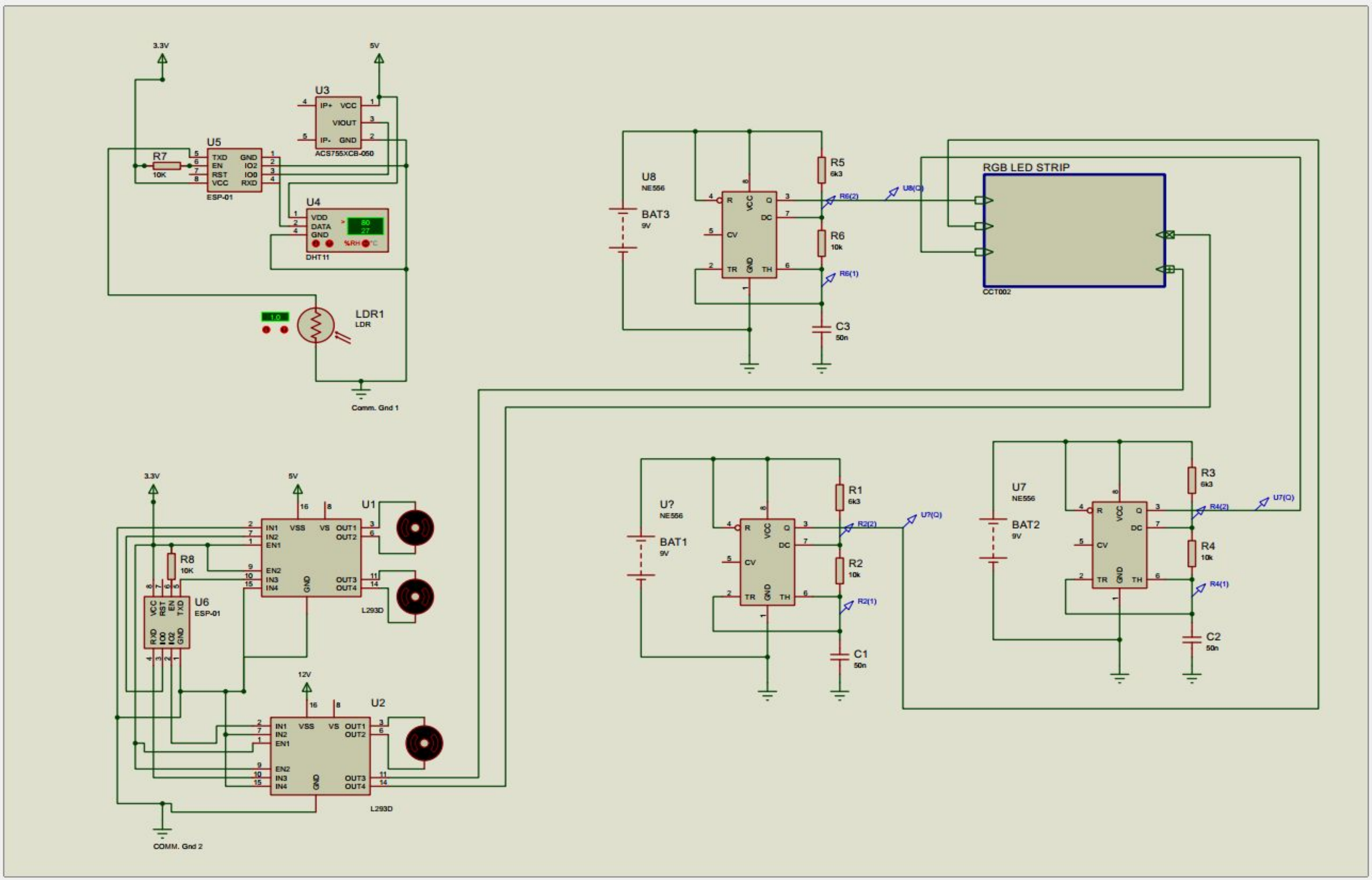
- **Microcontroller: ESP 01 (Espressif Systems)**
  - ESP8266EX chip
  - 32-bit RISC CPU operating at 80 MHz
  - Integrated TCP/IP stack for internet communication
  - Integrated Wi-Fi (802.11b/g/n)
  - Frequency Bands: 2.4 GHz (Wi-Fi)
- **Motor Driver: 2 x L293D Motor Driver IC**
  - Capable of driving two DC motors or one stepper motor per L293D
  - 4.5V to 36V supply voltage range with bi-directional drive current up to 600mA.
- **Temperature and Humidity Sensor: DHT11**
  - Temperature measurement range: 0°C to 50°C
  - Humidity measurement range: 20% to 90%
- **Camera: ESP32**
  - FPC connector.
  - Support for OV2640 (sold with a board) or OV7670 cameras.
  - Image Format: JPEG(OV2640 support only), BMP, grayscale.
  - LED flashlight.
  - Temperature Range: Operating: -20 ℃ ~ 85 ℃
  - Power Supply: 5V via pin header.
  - External Storage: micro SD card slot up to 4GB.

4. Block Diagram



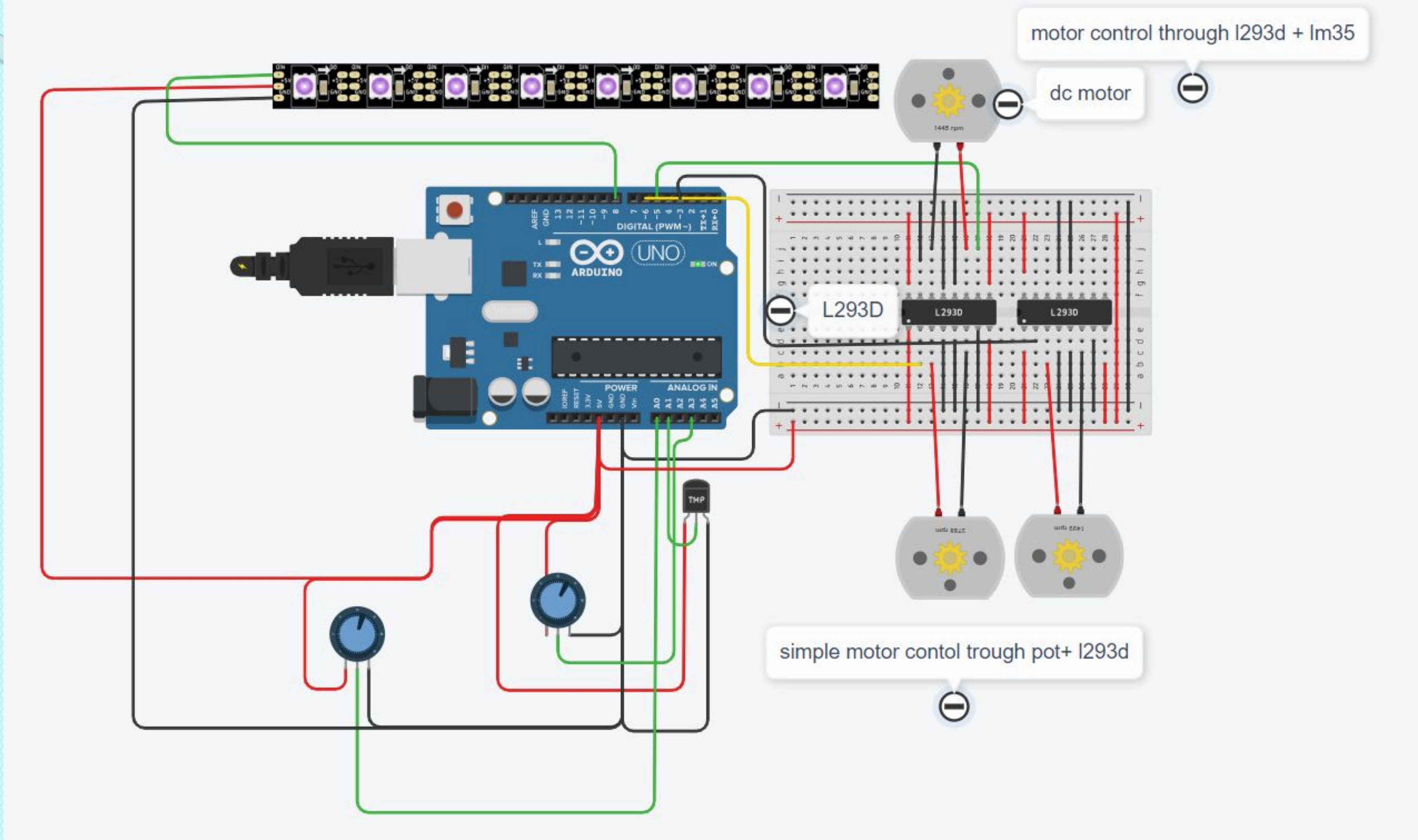
5. Hardware Design

5.1. Schematic



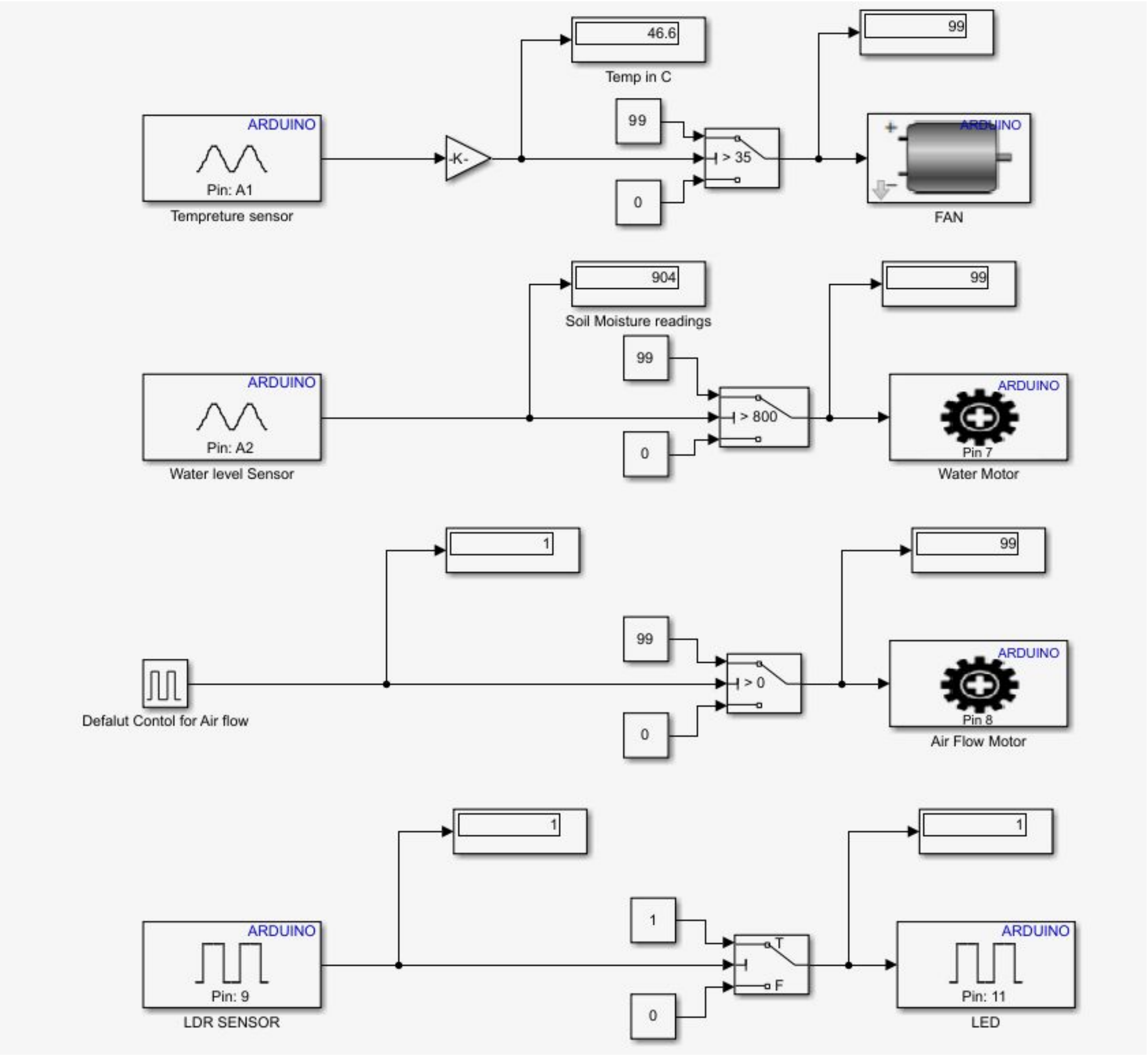
5. Hardware Design

5.2. Simulation



5. Hardware Design

5.3. Matlab Emulation



5. Hardware Design

5.4.1 Enclosure design of whole system

Material Used: Steel-Satin, Color Used: Metallic Brown ,Metallic Red

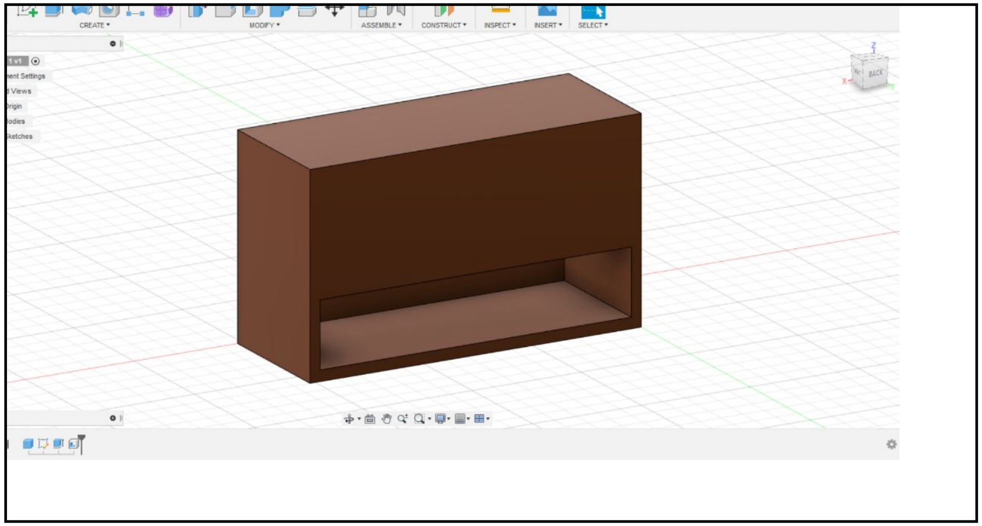


Fig 5.4.1: Enclosure design of whole system on fusion 360

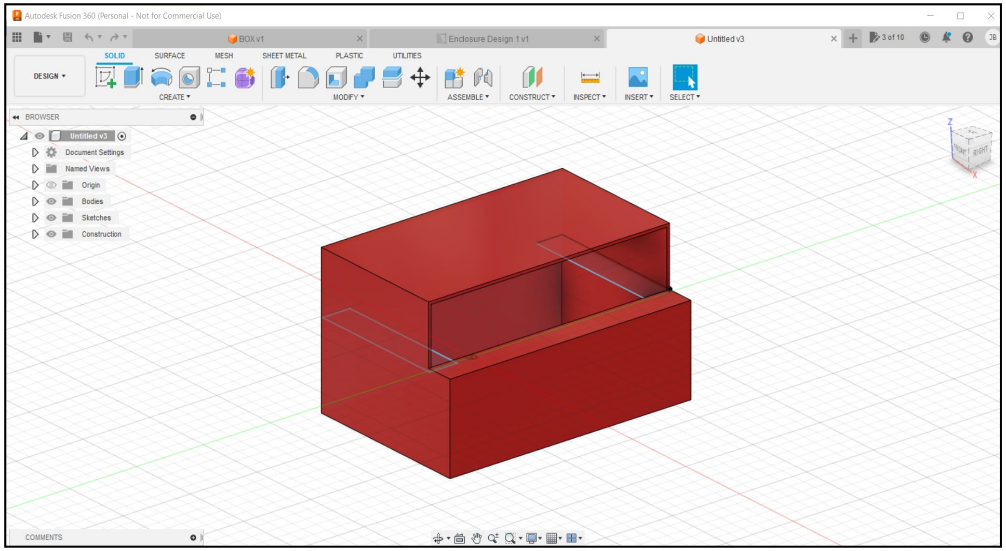


Fig 5.4.2: Enclosure design of whole system on fusion 360

5. Hardware Design

5.4.2 Enclosure design for NetPot, NFT Channel

Material Used: Steel-Satin , Color Used: Metallic Black,Metallic White

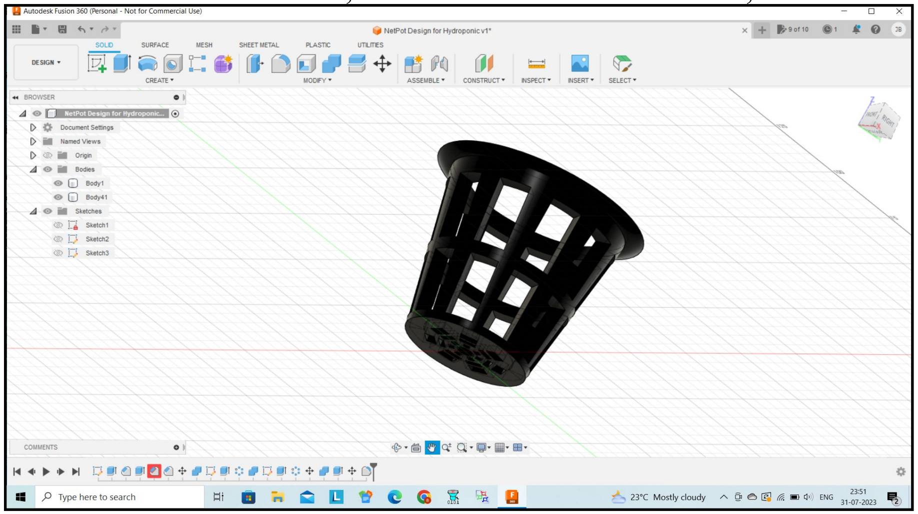


Fig 5.4.3: Enclosure design for NetPot on fusion 360

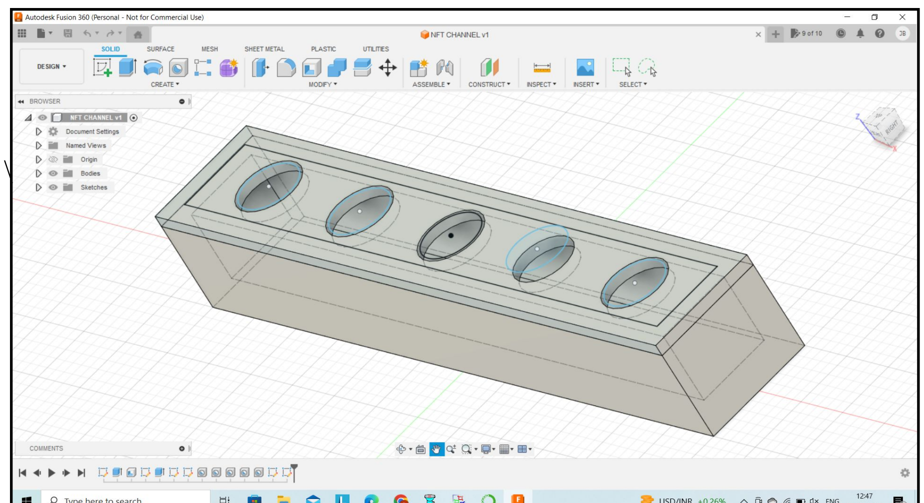


Fig 5.3.4: Enclosure design for NFT Channel on fusion 360

5. Hardware Design

5.4.3 Sketch Constraints

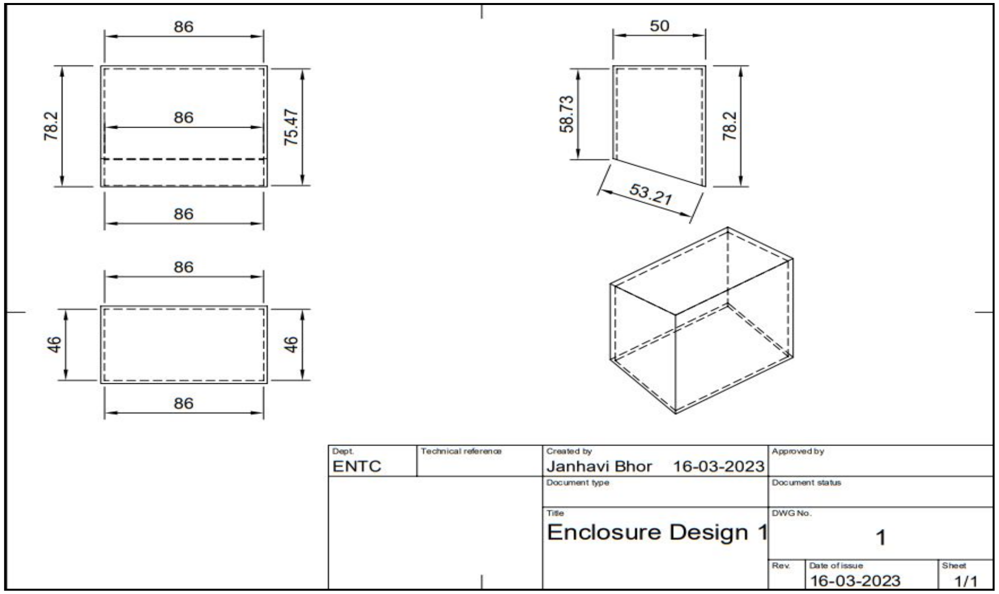


Fig 5.3.8: Sketch Constraint of Enclosure design 1 for controller on fusion 360

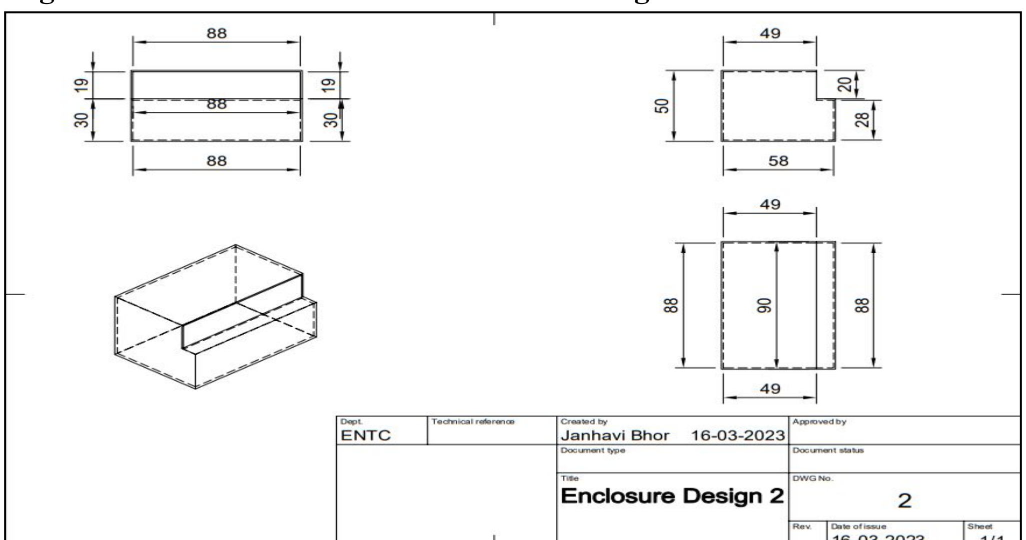


Fig 5.3.8: Sketch Constraint of Enclosure design 2 for controller on fusion 360

5. Hardware Design

5.4.4 Sketch Constraints

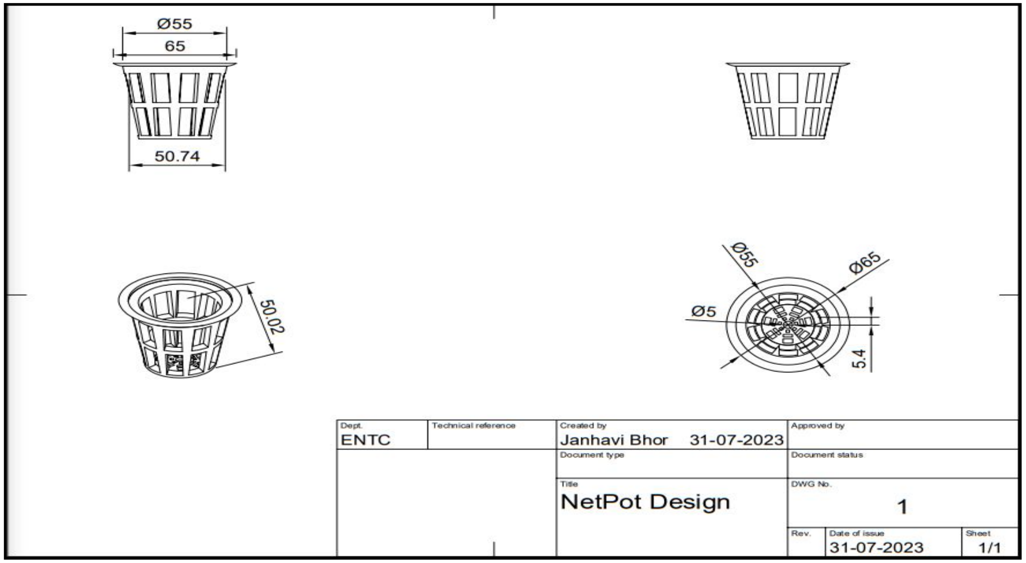


Fig 5.3.9: Sketch Constraint of Enclosure design of NetPot on fusion 360

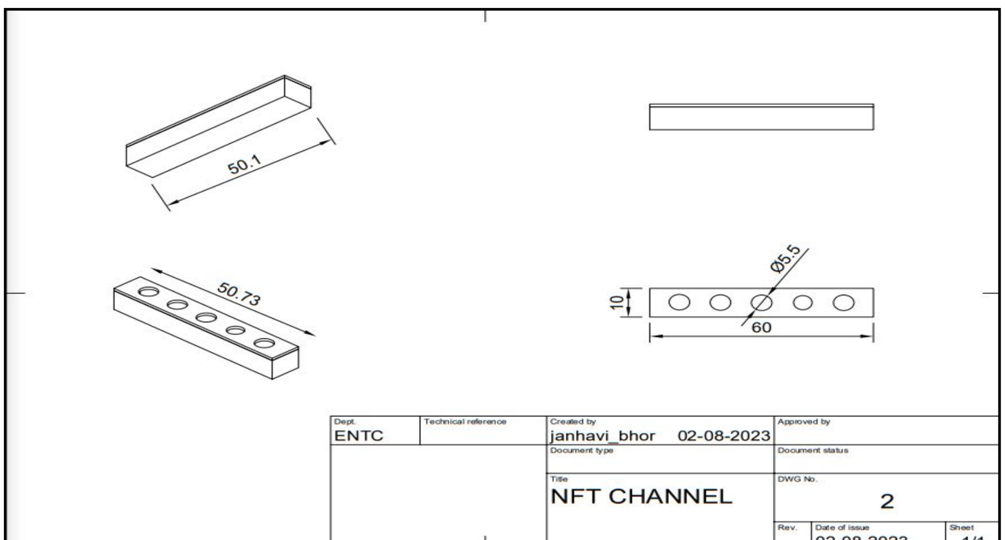
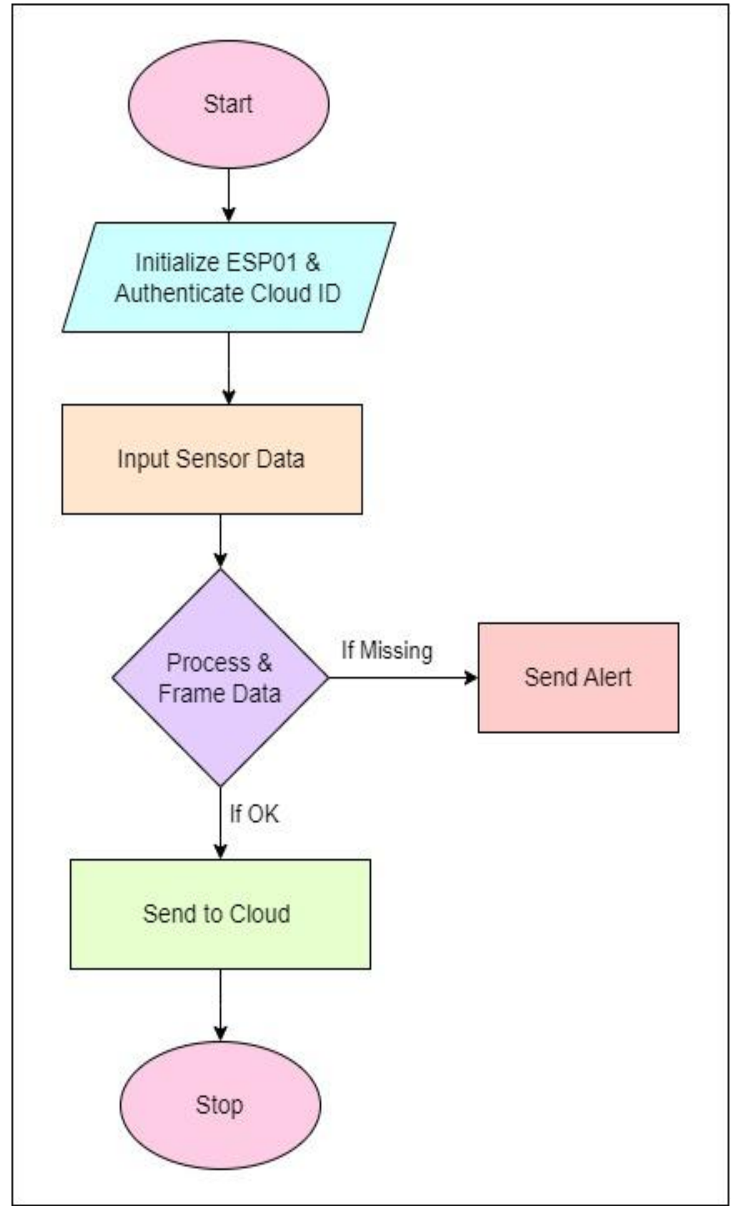


Fig 5.3.10: Sketch Constraint of Enclosure design of NFT Channel on fusion 360

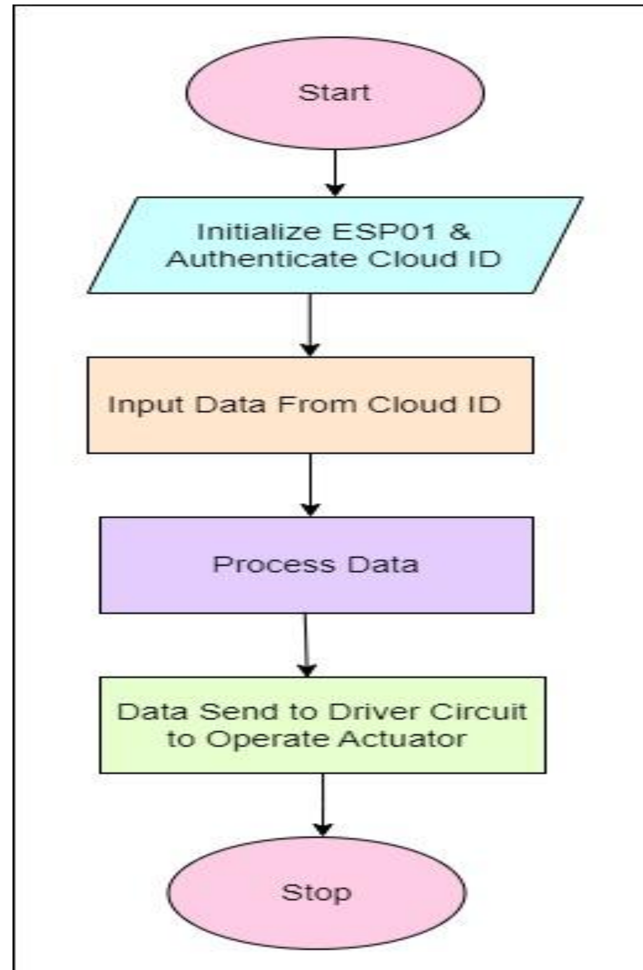
6. Software Design

6.1. Flow chart for sensors



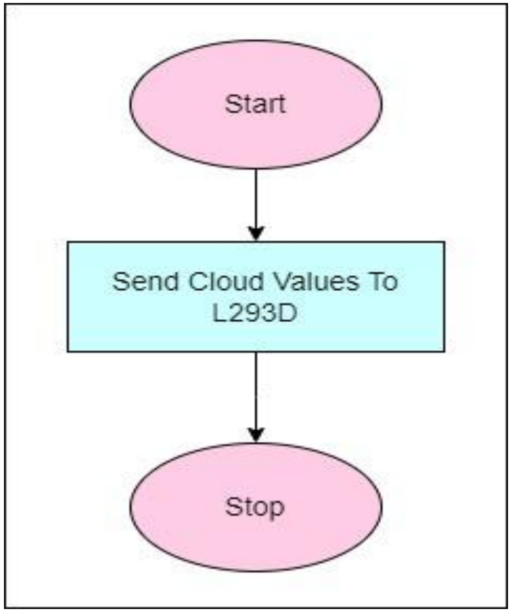
6. Software Design

6.2. Flow Chart for Actuators



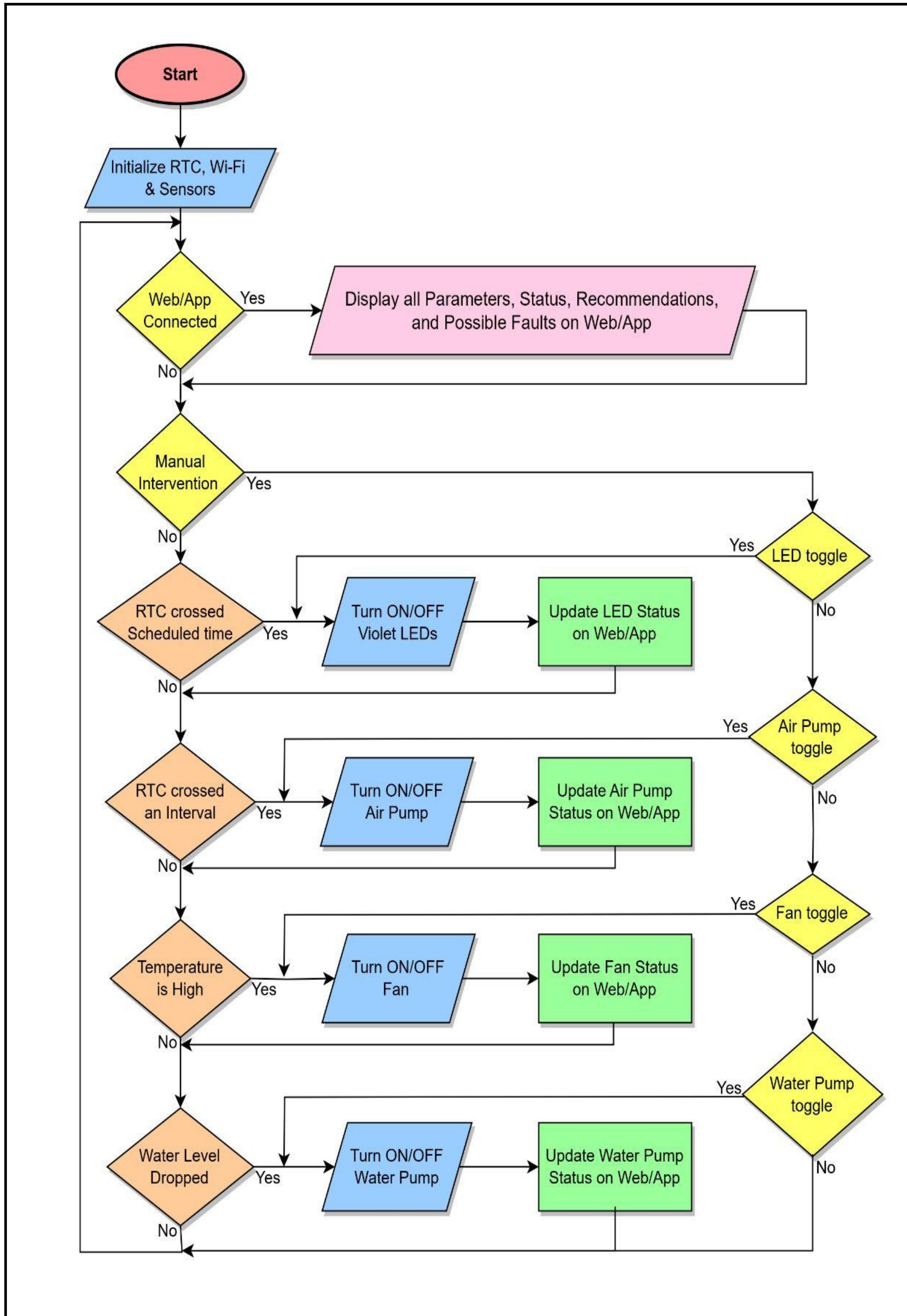
6. Software Design

6.3. Flow chart for Driver Circuit



6. Software Design

6.4. Flow chart of the system



7. Result

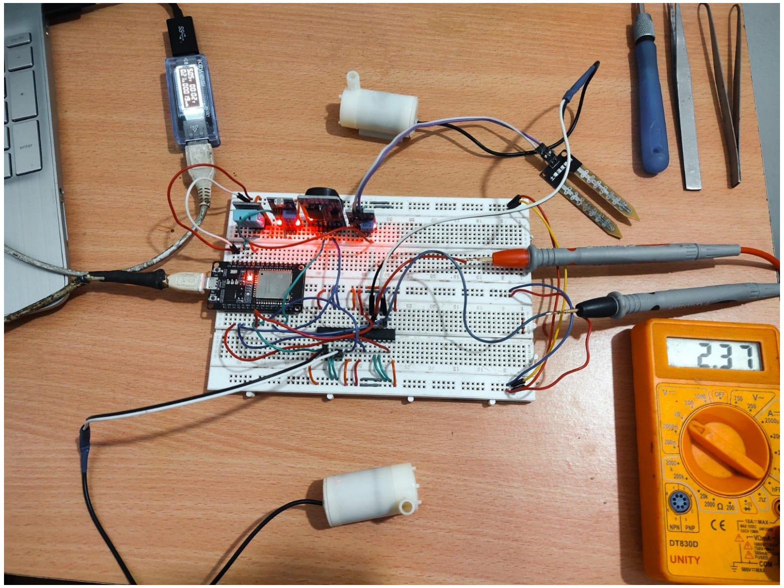


Fig. 7.1. Hardware for test case 1

Test case 1

- Testing and working of Driver circuit is shown.
- Multimeter meter is connected to visibly verify that motors are on.
- Power parameters are recorded and are under acceptable range

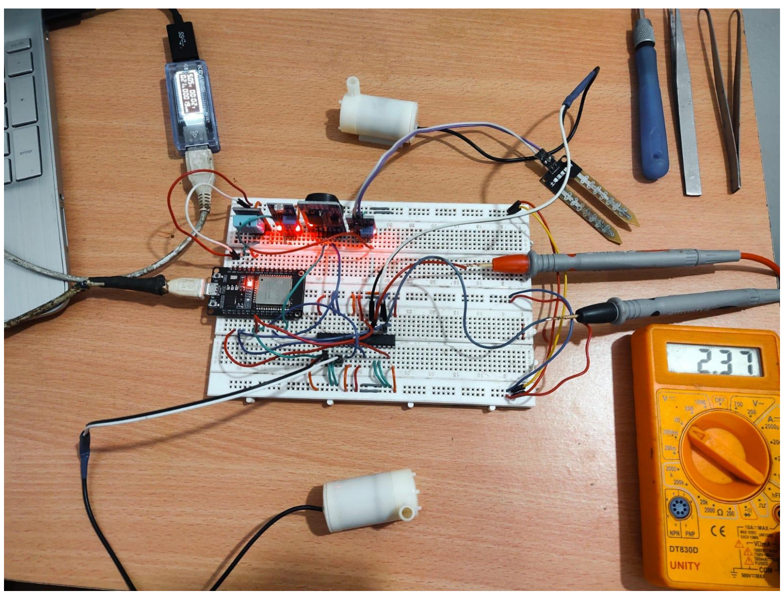


Fig. 7.2. Hardware for tes case 2

Test case 2

- Testing and working of Sensor and cloud integration is done.
- Same setup is used
- Both Cloud channel as well as a Global scale webpage is created to show case data

Result

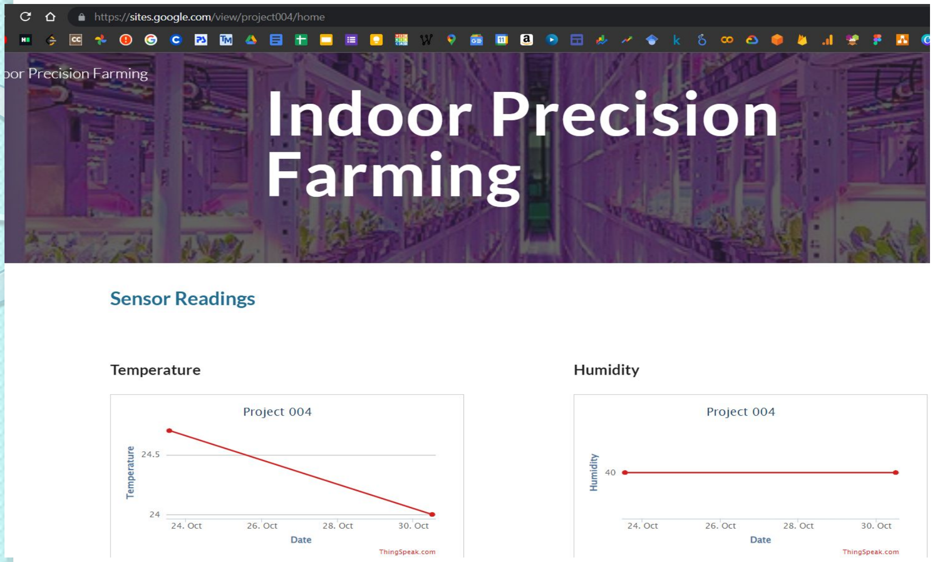


Fig. 7.3. webpage to show data

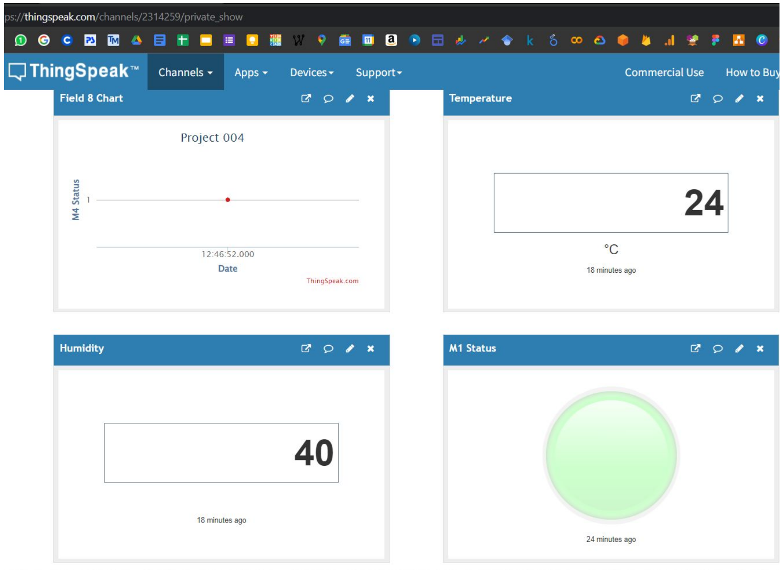


Fig. 7.4 Cloud integration

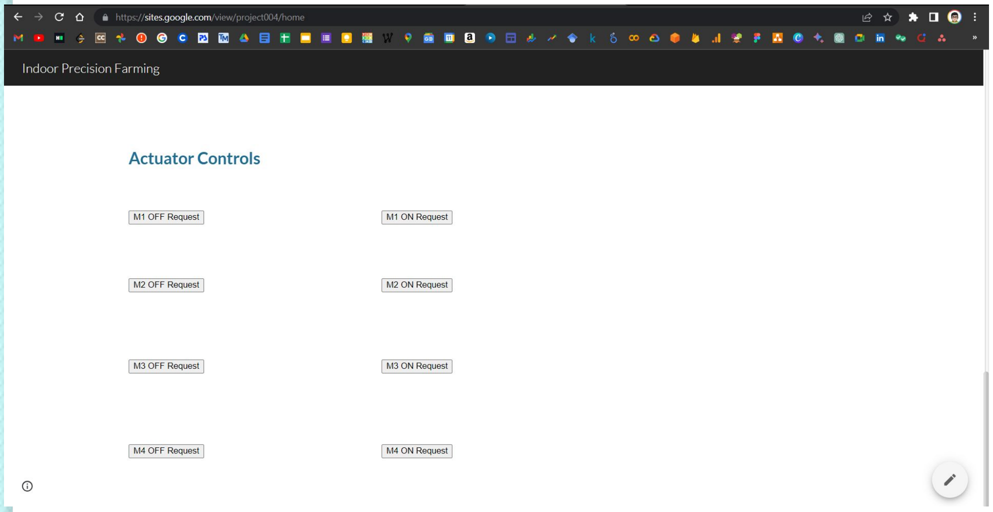


Fig. 7.5. Actuator control through webpage

Test case 3

- Testing and working of Motor actuators is done.
- Same setup is used
- Done using Global scale webpage.

8. Applications

- **Home gardening**: NFT hydroponics is an ideal method for home gardening, as it allows for year-round cultivation of fresh herbs, vegetables, and fruits. The system can be set up in a small space and can be easily maintained, making it a convenient and cost-effective option for home gardeners.

- **Commercial agriculture**: NFT hydroponics is also used in commercial agriculture for growing crops such as lettuce, herbs, and strawberries. The system is highly efficient, as it requires less water and space compared to traditional farming methods, leading to higher yields and reduced costs.

- **Urban farming**: NFT hydroponics is becoming increasingly popular in urban farming, as it allows for the cultivation of fresh produce in urban areas with limited space. The system can be set up in rooftops, balconies, or indoor spaces, providing a sustainable and efficient method for urban farming.

- **Research and education**: NFT hydroponics is used in research and education to study plant growth and development in a controlled environment. The system allows researchers and students to manipulate the nutrient composition and environmental factors to study the effects on plant growth and development.

- Aquaponics
- Hydroponics
- Aeroponics

9. Month wise Plan of Action

Month	Activites	Weeks(approx.)
July	Define the Project synopsis. Since this is an extended project we will Identify new objectives, constraints, and requirements and expected outcomes and innovation.	1-2
	Research and Literature Review. we will study existing IoT and embedded system projects and relevant technologies. and Review academic papers, books, and online resources to rebuild a strong theoretical foundation.	3-4
August	Create a presentation and have a Industry expert interaction.	1-2
	Write a Review paper based on our current understanding	3-4

September	Expected insem examination	1-2
	Design Appropriate Simulation ,expected schematics and design enclosure design	3-4
October	Procurement and functional Testing of components	1-2
	Test case implementation	3-4
November	Give a seminar	1
	Expected diwali holiday	2-3
	Expected end sem exam	4
December	Expected end sem exam	1-2
	Final Procurement	3-4
January	End Case simulation and schematics	1-2
	Prototype integration and testing	3-4
February	Expected Exams	1
	Expected ensem exams	2
	Enclosure Manufacturing	3-4

March	final integration	1-2
	Rearch paper writing, live plant growth in the system	3-4
April	Patent Application Searching	1-2
	data recordings	3-4
May	Competition participation	1-4
June	endsem Presentation	-

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