A PDR PROJECT REPORT

On

SMART HERB PLANTER

Submitted in Partial Fulfillment of Award of

BACHELOR OF TECHNOLOGY
In
COMPUTER SCIENCE ENGINEERING

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April 2025

ALLIANCE SCHOOL OF APPLIED ENGINEERING/ALLIANCE SCHOOL OF ADVANCED COMPUTING

DECLARATION

We hereby declare that the report on product design and realization submitted by me in the partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Aerospace Engineering of Alliance University, is a record of my work carried under the supervision **Harinath Aireddy (Associate Professor, ECE).**

We confirm that this report truly represents the work undertaken as a part of Product design and realization. This work is not a replication of work done previously by any other person. We also confirm that the report's contents and views have been discussed and deliberated with the academic advisor.

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CERTIFICATE

This is to certify that the report on product design and realization is submitted by , Nikhil V (2411021060973), Armaan S (2411021060986), Yashas Raj S A (2411021060990), Guddanti Nikhil Srinivas (2411021060939), Vatam Hanvesh Reddy (2411021060937), Poojari Karthikeyulu (2411021060938), in partial fulfillment for the award of the degree of Bachelor of Technology Aerospace Engineering of Alliance University, is a Bonafide work accomplished under our supervision and guidance during the academic year 2024-2025. This report embodies the results of original work and studies conducted by students and the contents do not form the basis for the award of any other degree to the candidate or anybody else.

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1. INTRODUCTION

1.1 BRIEF OVERVIEW OF ADDITIVE MANUFACTURING AND ITS SIGNIFICANCE.

Additive Manufacturing:

Additive Manufacturing, or 3D printing, is a process of building three-dimensional objects by sequentially adding material layer by layer, from a digital model (most commonly a CAD file). This is the opposite of subtractive manufacturing, where material is subtracted from a solid block through processes such as machining, drilling, or milling.

The process of AM involves the following steps:

- Creation of a 3D model using CAD software.
- Slicing the model into thin layers with the help of slicing software.
- Printing the object in layers with a suitable 3D printer and material.
- Post-processing consists of cleaning, curing, or finishing the printed component.

Types of Additive Manufacturing Technologies

1. Fused Deposition Modeling (FDM):
    - Works with thermoplastic filaments (PLA, ABS).
    - Material extruded from a heated nozzle.
    - Typical of desktop 3D printers.

2. Stereolithography (SLA):
    - Works with a UV laser to solidify liquid resin layer by layer.
    - Recognized for high-resolution prints and even surface finish.

3. Selective Laser Sintering (SLS):
    - Utilizes a laser to sinter metal or plastic powder.
    - No support structures required because of powder bed.
    - Ideal for functional prototypes and end-use parts.

4. Direct Metal Laser Sintering (DMLS):
    - Same as SLS but applied to metals.
    - Used in aerospace and medical fields.

5. Electron Beam Melting (EBM):
    - Utilizes an electron beam to melt metal powder.
    - Operates in a vacuum environment, best suited for titanium and similar metals.

Importance Of Additive Manufacturing

1. Freedom of Design and Customization

- Enables the production of complex geometries, internal structures, and organic forms that are not possible with conventional manufacturing.
- Facilitates mass customization, where every product can be customized to specific requirements (e.g., prosthetics, dental implants).

2. Rapid Prototyping

- Reduces the product development cycle.
- Designers and engineers can rapidly test and iterate designs.
- Decreases time to market and development costs.

3. Material Efficiency and Sustainability

- Low material waste compared to conventional methods.
- Utilizes only the amount of material necessary to create the part.
- Facilitates use of recyclable or biodegradable materials.

4. On-Demand and Decentralized Production

- Minimizes mass production and storage requirements.
- Favors manufacturing in proximity to end-users, lowering transportation costs and emissions.
- Able to be useful for remote or crisis scenarios (e.g., printing of tools or parts in space or disaster areas).

5. Lightweighting and Performance Optimization:

- Significance in aerospace and automotive industries.
- Lightweight lattice structures minimize weight without loss of strength.
- Improves performance and fuel efficiency.

6. Tool-less Manufacturing

- Reduces or eliminates the need for molds, dies, and special tooling.
- Decreases the entry barrier for small-scale manufacturing and startups.

7. Industry Innovation

- Healthcare: Implants, prosthetics, and even organs printed in research stages.
- Aerospace: High-performance, lightweight parts for aircraft and satellites.
- Automotive: Functional prototypes, custom tools, and even end-use production components.
- Construction: 3D-printed buildings and houses made from concrete-like materials.

Challenges And Future Outlook

- Although additive manufacturing has numerous benefits, challenges are:
- Limited scalability and speed for high-volume production.
- Surface finish and strength can need post-processing.
- Industrial-grade printers and materials are very expensive.
- Regulatory barriers, particularly in safety-critical applications (e.g., aerospace, medicine).

Future Trends:

- Hybrid manufacturing (additive and subtractive combined).
- New materials development (e.g., ceramics, composites).
- AI and simulation integration for design optimization.
- Increased use in supply chains for digital inventory.

Additive Manufacturing is revolutionizing how we design, prototype, and produce products. With its power to produce complicated, tailored, and light structures with minimal wastage and expenses, AM is opening doors towards more sustainable, efficient, and innovative production within industries.

1.2 CONTEXT OF THE REAL-WORLD PROBLEM

With the busy urban life of today, most individuals are resorting to indoor gardening to cultivate herbs and small plants for domestic use. Yet, it is difficult to have healthy plant growth indoors because of inconsistent watering, insufficient environmental control, and limited horticultural expertise. This tends to result in plant stress, underwatering, or over-watering—particularly when the user is absent or too busy.

Additionally, conventional planters do not have intelligent monitoring and automation and need constant human intervention. The demand for a low-maintenance, efficient, and intelligent plant care system has become more pertinent, particularly for apartment residents, working professionals, and new gardeners.

To solve this issue, we introduce a **Smart Herb Planter** that integrates capillary action, sensor-based monitoring, and IoT-enabled automation to provide optimal plant health with minimal user intervention.

1.3 OBJECTIVES OF THE PROJECT.

- Design and prototype a self-watering herb planter that:
- Utilizes capillary action for even water distribution.
- Includes smart sensors to track temperature, humidity, soil moisture, and water levels.
- Automates water supply and climate control using real-time inputs.
- Enables users to remotely control and monitor the system using Blynk IoT.

2. PROBLEM STATEMENT

2.1 Clearly Define the Real-World Problem Being Solved

In contemporary city life, caring for healthy plants, particularly indoor herb cultivation, is a daunting task because of inconsistent watering routines, climatic changes, and limited gardening experience. Conventional planters need constant human intervention and provide no mechanized feedback and control, resulting in plant stress, underwatering, or over-watering. Not only does this cause plant death but also deters individuals from engaging in eco-friendly activities such as home gardening.

Although smart gardening systems are available, they tend to be costly, complicated, or lacking in water efficiency and environmental sensitivity. There is obviously a demand for an economical, efficient, and smart self-watering system that reduces human care and promotes maximum plant health, particularly for novices, busy professionals, and residents of urban apartments.

2.2 Justify the relevance of the problem and its impact:

Justification And Relevance

Why This Problem Matters:

Urban Living Challenges:

- The majority of urban dwellers reside in apartments with minimal garden access.
- Space limitations render conventional gardening infeasible.
- Indoor gardening is trendy but constrained by maintenance challenges.

Time and Skill Constraints:

- Busy lifestyles provide minimal time for frequent plant maintenance.
- Numerous individuals do not possess the knowledge to effectively track plant requirements.

Environmental and Economic Impact:

- Manual watering results in wastage of water.
- Replacing dead plants adds expense and discouragement for users.
- Increasing Demand for Intelligent Solutions:
- IoT and smart homes are gaining traction.
- Customers are demanding more automated, green, and DIY-friendly technology.

Impact

- Empowers Users: Simplifies and makes more dependable indoor gardening for users of all abilities.
- Reduces Resource Waste: Saves water and energy through effective, sensor-based operation.
- Improvements in Plant Health: Provides ideal growing conditions through real-time environmental monitoring and automation.
- Scalability: Provides a modular solution that can be expanded or modified for various plant species and rooms.
- Personal Level:
  Decreases plant death and boosts confidence among novice gardeners.
  Promotes healthier living by easy access to home-grown herbs.

- Environmental Level:
  Saves water through sensor-based precision and capillary action.
  Facilitates sustainable practices and minimizes carbon footprint (e.g., reduced use of store-bought herbs).
- Technological Innovation:
  Exemplifies a smart, low-cost implementation of IoT, 3D printing, and automation.
  Fosters interdisciplinary learning and innovation (mechanical design + electronics + software + materials science).

3.METHODOLOGY

The Smart Self-Watering Herb Planter will be developed using a structured approach that integrates 3D-printed capillary action systems, sensor-based monitoring, and IoT automation. This ensures optimal plant growth with minimal human intervention.

Step 1: Structural Design & Fabrication

The planter's design will focus on lightweight, durable, and water-efficient materials. The following steps ensure success:

- Lattice Wall Structure: For airflow and weight reduction without compromising strength.
- Capillary Watering System: Designed using the Lucas-Washburn equation to optimize water absorption:

Step 2: Material Selection & 3D Printing:

- Frame: PETG (water-resistant, strong).
- Capillary Channels: SLA Resin (high precision for efficient water transport).
- Valves & Tubing: TPU (flexible, durable).

Step 3: Smart Sensor Integration & IoT Automation

The system will utilize ESP32 to control and monitor essential parameters via IoT:

- Soil Moisture Sensor: Measures soil hydration, preventing over/underwatering.
- DHT22 Sensor: Tracks temperature & humidity for environmental adjustments.
- Water Level Sensor: Ensures the reservoir has enough water.
- Peristaltic Pump: Activated if moisture drops below a threshold.
- Temperature Control using Bulb and Mist maker: Activates 100 watt bulb and 24 volts humidifier if temperature fluctuates.

Automated Watering Logic:

If Moisture $<$ Threshold AND Water Level $>$ Minimum, Activate Pump

Figure 1. Motor Control Logic

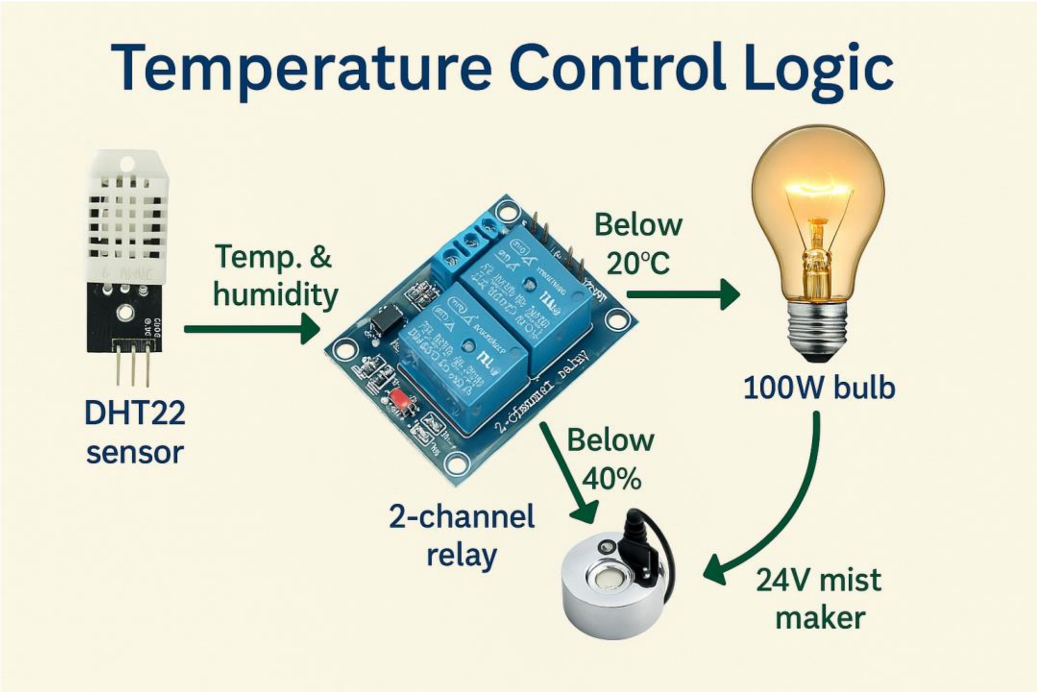

Figure 2. Temperature Control Logic

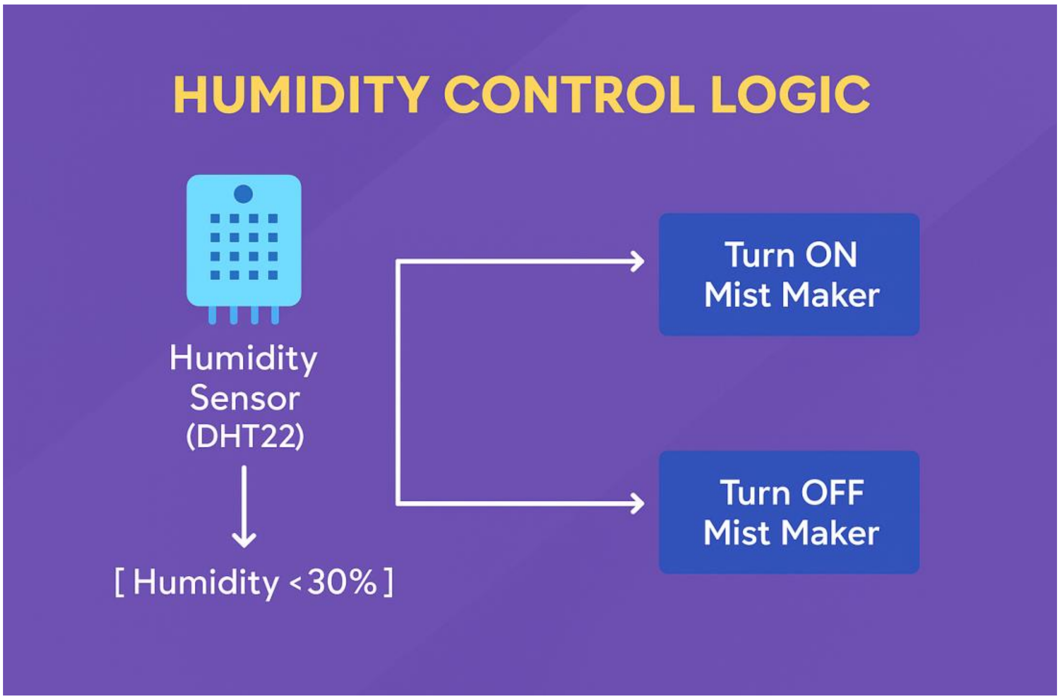

Figure 3. Humidity Control Logic

This ensures efficient watering while avoiding wastage.

- Blynk IoT Dashboard:
  -Remote monitoring & control via smartphone.
  -Real-time alerts for low water levels or soil dryness.

Step 4: Power Management & Efficiency:

To ensure sustainability, the system will:

- Use Low-power ESP32 deep sleep mode to reduce energy consumption.
- Operate on a 5V/2A adapter or solar panel for off-grid functionality.

Step 5: Testing & Optimization

The project will be validated through a 3-phase testing approach:

- Phase 1: 3D Prototype Testing
  - Evaluate capillary action efficiency in different soil types.
  - Check the mechanical durability of 3D-printed components.
- Phase 2: Sensor & Circuit Testing
  - Calibrate soil moisture sensor for accuracy.
  - Ensure pump activation timing aligns with soil needs.
- Phase 3: IoT & User Experience Testing
  - Test real-time data updates via Blynk.
  - Optimize data logging & alert thresholds for better usability.

Arduino code:

```
#include <Wire.h>

#include <U8g2lib.h>

#include <DHT.h>

#include <WiFi.h>

#include <BlynkSimpleEsp32.h>


// WiFi Credentials

char ssid[] = "YOUR_WIFI_SSID";

char pass[] = "YOUR_WIFI_PASSWORD";


// Blynk Auth Token

char auth[] = "YOUR_BLYNK_AUTH_TOKEN";
```

```
// OLED SH1106 I2C
U8G2_SH1106_128X64_NONAME_F_HW_I2C u8g2(U8G2_R0, /* reset=*/
U8X8_PIN_NONE);


// DHT22 Setup
#define DHTPIN 4
#define DHTTYPE DHT22
DHT dht(DHTPIN, DHTTYPE);


// Soil Moisture
#define SOIL_PIN 34


// Ultrasonic JSN-SR04T
#define TRIG_PIN 12
#define ECHO_PIN 14
#define TANK_HEIGHT_CM 30


// Relay Pins
#define RELAY_MOTOR 26
#define RELAY_BULB 27
#define RELAY_MIST 25


// Blynk Virtual Pins
#define VPIN_TEMP V0
#define VPIN_HUM V1
#define VPIN_SOIL V2
#define VPIN_WATER V3
#define VPIN_MODE V4
#define VPIN_BULB V5
#define VPIN_MIST V6
```

```
#define VPIN_MOTOR V7

bool autoMode = true;

void setup() {
  Serial.begin(115200);
  dht.begin();
  u8g2.begin();
  Blynk.begin(auth, ssid, pass);

  pinMode(TRIG_PIN, OUTPUT);
  pinMode(ECHO_PIN, INPUT);

  pinMode(RELAY_MOTOR, OUTPUT);
  pinMode(RELAY_BULB, OUTPUT);
  pinMode(RELAY_MIST, OUTPUT);

  digitalWrite(RELAY_MOTOR, LOW);
  digitalWrite(RELAY_BULB, LOW);
  digitalWrite(RELAY_MIST, LOW);
}

// Manual Control Handlers
BLYNK_WRITE(VPIN_MODE) {
  autoMode = param.asInt();
}

BLYNK_WRITE(VPIN_MOTOR) {
  if (!autoMode) digitalWrite(RELAY_MOTOR, param.asInt());
}
```

```
BLYNK_WRITE(VPIN_BULB) {
  if (!autoMode) digitalWrite(RELAY_BULB, param.asInt());
}

BLYNK_WRITE(VPIN_MIST) {
  if (!autoMode) digitalWrite(RELAY_MIST, param.asInt());
}

long readDistanceCM() {
  digitalWrite(TRIG_PIN, LOW);
  delayMicroseconds(2);
  digitalWrite(TRIG_PIN, HIGH);
  delayMicroseconds(10);
  digitalWrite(TRIG_PIN, LOW);

  long duration = pulseIn(ECHO_PIN, HIGH, 30000);
  if (duration == 0) return TANK_HEIGHT_CM;
  return duration * 0.034 / 2;
}

void loop() {
  Blynk.run();

  float temp = dht.readTemperature();
  float hum = dht.readHumidity();

  int soilRaw = analogRead(SOIL_PIN);
  int soilPercent = map(soilRaw, 4095, 1500, 0, 100);
  soilPercent = constrain(soilPercent, 0, 100);
```

```
long distance = readDistanceCM();
int waterLevel = map(TANK_HEIGHT_CM - distance, 0, TANK_HEIGHT_CM, 0, 100);
waterLevel = constrain(waterLevel, 0, 100);

String motorStatus = "OFF";
String bulbStatus = "OFF";
String mistStatus = "OFF";

if (autoMode) {
  if (soilPercent < 30) {
    digitalWrite(RELAY_MOTOR, HIGH);
    motorStatus = "ON";
  } else if (soilPercent >= 45) {
    digitalWrite(RELAY_MOTOR, LOW);
    motorStatus = "OFF";
  }

  if (temp < 20) {
    digitalWrite(RELAY_BULB, HIGH);
    bulbStatus = "ON";
  } else {
    digitalWrite(RELAY_BULB, LOW);
    bulbStatus = "OFF";
  }

  if (hum < 40) {
    digitalWrite(RELAY_MIST, HIGH);
    mistStatus = "ON";
  } else {
```

```
    digitalWrite(RELAY_MIST, LOW);
    mistStatus = "OFF";
  }
} else {
  motorStatus = digitalRead(RELAY_MOTOR) ? "ON" : "OFF";
  bulbStatus = digitalRead(RELAY_BULB) ? "ON" : "OFF";
  mistStatus = digitalRead(RELAY_MIST) ? "ON" : "OFF";
}

// Blynk
Blynk.virtualWrite(VPIN_TEMP, temp);
Blynk.virtualWrite(VPIN_HUM, hum);
Blynk.virtualWrite(VPIN_SOIL, soilPercent);
Blynk.virtualWrite(VPIN_WATER, waterLevel);

// Serial Debug
Serial.printf("Temp: %.1f°C | Hum: %.1f%% | Soil: %d%% | Water: %d%% | Mode: %s | Pump: %s | Bulb: %s | Mist: %s\n",
              temp, hum, soilPercent, waterLevel,
              autoMode ? "Auto" : "Manual",
              motorStatus.c_str(), bulbStatus.c_str(), mistStatus.c_str());

// OLED Display
u8g2.clearBuffer();
u8g2.setFont(u8g2_font_6x13_tf);
u8g2.setCursor(0, 12);
u8g2.printf("Temp: %.1f C", temp);
u8g2.setCursor(0, 24);
u8g2.printf("Hum : %.1f %%", hum);
u8g2.setCursor(0, 36);
u8g2.printf("Soil: %d %%", soilPercent);
```

```
  u8g2.setCursor(0, 48);
  u8g2.printf("Water: %d %%", waterLevel);
  u8g2.setCursor(0, 60);
  u8g2.printf("P:%s B:%s M:%s", motorStatus.c_str(), bulbStatus.c_str(), mistStatus.c_str());
  u8g2.sendBuffer();

  delay(2000);
}
```

Pin Configuration:

Component	ESP32 Pin
DHT22	4
Soil Moisture	34
Water Level Trigger Echo	12 14
Motor Relay	32
Bulb Relay	25
Humidifier Relay	26
OLED (2C Power Mode Temperature Humidifier	21 22

Figure 4. ESP32 pin configuration

4.DESIGN PROCESS AND 3D PRINTING DESCRIPTION

4.1 Design Process (Under Progress)

a) Ideation & Functional Planning:
We started the design process with a humble thought: making a smart, small, and easy-to-use herb planter that can tend to itself. We established the fundamental functions of the system:
- Sensing environmental parameters (temperature, humidity, soil moisture, and water level)
- Automatically reacting to those readings (watering, regulating humidity, and supplying heat)
- Facilitating remote monitoring and control using Blynk IoT
- Showing real-time information on a small OLED display

b) Rough Sketches & Layout:
Early hand sketches and digital renderings assisted in visualizing the spatial organization of all major parts. Zones were established for the plant bed, water reservoir, electronics compartment, and lamp arm.

c) Component Sizing & Placement:
Each component was measured to a specific size—including the ESP32, DHT22, soil moisture sensor, OLED display, JSN-SR04T, relays, motor pump, and humidifier. The design included dedicated slots and mounts for each.

d) Form Factor & Usability:
We desired a minimalist, streamlined appearance with curvilinear edges and a modular design. User interaction components (buttons, screen, refill cap) were placed for convenience of use and visual acknowledgment.

4.2 Steps in 3D Modeling

a) Drawing Components

In CAD software (like Fusion 360), 2D drawings of every component were done, including:

- Main base with plant bed and water tank
- Electronics housing
- Lamp arm holder
- Sensor mounts
- Refill lids and holes

b) Extruding to 3D
The sketches were extruded to produce 3D components. The structural integrity was optimized with optimal wall thickness at the same time as material was saved.

c) Internal Structures & Partitions
The interior was separated into watertight chambers for electronics, water, and soil. Wires' routing paths and mounting holes for parts were also provided.

d) Tolerances & Fitting
Suitable tolerances (usually 0.2–0.5 mm) were used for slots as well as moving parts so that after printing, there would be no fitting complications.

e) Assembly Simulation
The entire model was nearly put together to confirm alignment and stability of all pieces prior to sending design files off to be sliced.

4.3 Problem-Solving Method

a) Space Restriction
For holding all parts in a minimalistic design, stacking vertically was utilized. Cable channels were implemented inside and the lamp arm raised.

b) Waterproofing of Electronics
An enclosed electronics housing was created, using silicone grommet entry points to protect the electronics while safely guiding cables, keeping water from the electronics.

c) Heat Management
In order to control the heat produced by the 100W bulb, a heat-resistant ABS arm and ventilated frame were employed. Adequate spacing was maintained to safely dissipate heat.

d) Power Cable Routing
Power cables were taken inside via internal channels to declutter and minimize exposure to moisture.

e) Ease of Assembly
Snap-fit mechanisms and regular M3 screw holes were employed for easy, tool-free assembly and maintenance or future modifications.

4.4 Materials Used

Component Reasons:
- Main Body & Base PETG Durable, water-resistant, and suitable for prolonged contact with soil/water
- Bulb Arm & Support ABS Heat-resistant, ideal for components exposed to the 100W bulb
- Electronics Compartment PLA Easy to print, accurate for mounting electronic boards
- OLED & Sensor Mounts PLA Lightweight and dimensionally precise
- Capillary Base & Tray Resin (SLA) High precision, smooth flow channels for capillary action
- Transparent Lid (Optional) TPU Flexible, durable, and ideal for repeated use

4.5 3D Print Settings

Setting Value/Details:
- Layer Height : 0.2 mm (balanced quality and speed)
- Infill : 20% for main body; 50% for structural elements (e.g., lamp arm)
- Wall Thickness : 1.2 mm
- Print Speed : 50 mm/s
- Supports : Enabled (only where needed, e.g., overhangs)
- Bed Adhesion
- Brim for wide parts; Raft for narrow or complex components
- Nozzle Temp (PLA) : 200–210°C
- Nozzle Temp (PETG) : 235–250°C
- Bed Temp (PLA) : 60°C
- Bed Temp (PETG) : 80°C
- Slicer Used : Ultimaker Cura
- Nozzle Diameter : 0.4 mm (balanced for strength and detail)

All print settings were optimized to produce strong, accurate parts good enough for functional, everyday use in a self-watering planter.

4.6 Developed Model Design:

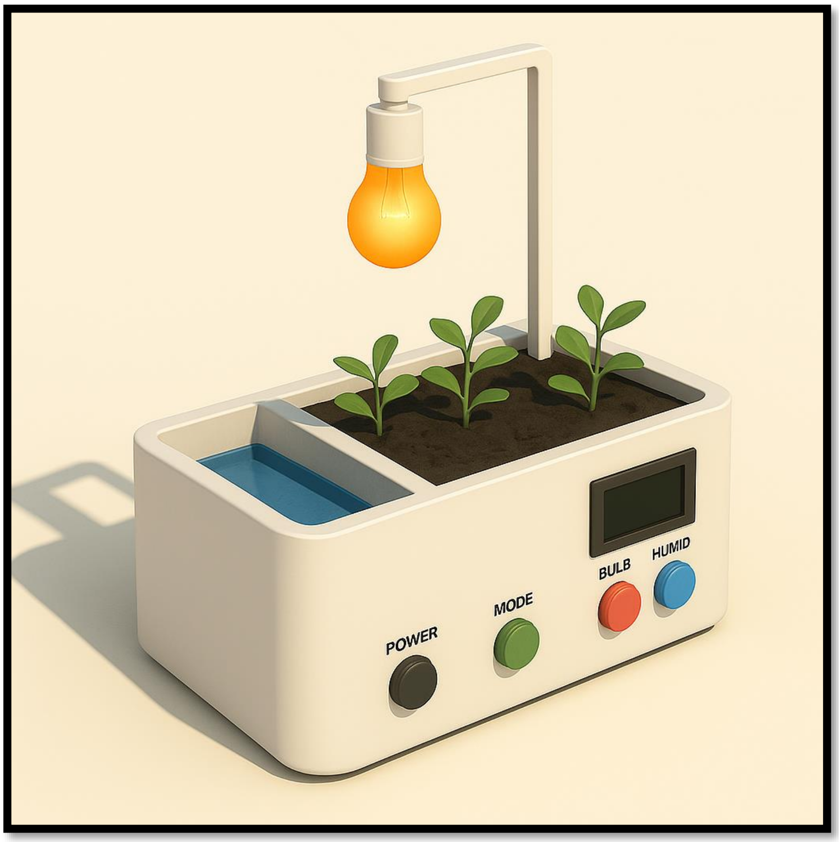

Figure 5. Developed Model Design

5.RESULT AND ANALYSIS

5.1 Photos of the Final Product

The final prototype of the Smart Herb Planter successfully integrates all key components into a compact, sleek, and modular design. The 3D-printed casing houses the soil chamber, water tank, OLED screen, sensors, relays, and physical buttons in a clean and intuitive layout.

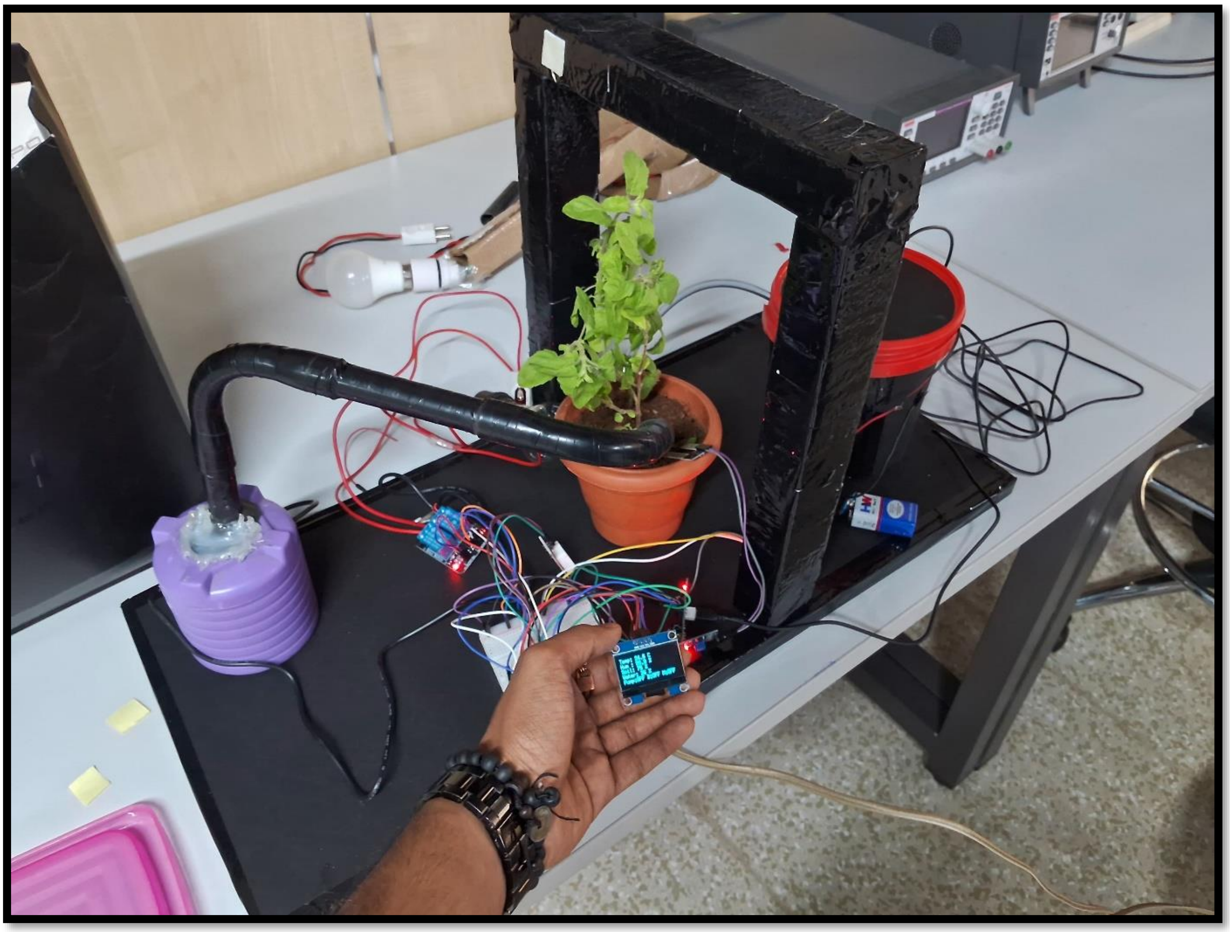

Figure 6. Photo of Final Product

5.2 Assessing Functionality, Performance, and Design Success

Functionality:

The system was validated under Auto and Manual modes using the physical interface and the Blynk app. All functions critical to operation, such as detecting soil moisture, monitoring water levels, temperature and humidity adjustment, and powering the motor, bulb, and humidifier, functioned smoothly. Sensor readings in real time were shown on the OLED display and synchronized with the Blynk dashboard. Switching modes and controlling components were seamless and quick under vari

ous conditions.
Performance

Readings from the DHT22 sensor, capacitive soil moisture sensor, and JSN-SR04T ultrasonic sensor were responsive and accurate.
The 100W bulb and 5V humidifier were automatically triggered when the set environmental conditions (humidity level less than 40%, temperature less than 20°C) were met. The system responded quickly with no delay in switching the relay and maintained ideal growing conditions for the plants constantly.

Design Success:
The enclosure, printed with a mix of PETG for structural integrity and TPU for flexible parts, fulfilled all design specifications regarding durability, layout, and usability. Every electronic component is securely fitted, with sensible cable management and room for airflow. The interface features good labeling, tactile buttons, and a readable OLED screen. The water tank is readily accessible for filling, and the soil chamber provides adequate depth for herb growth. The end product not only achieves the technical objective of monitoring and automation but also has a neat and contemporary look, which can be used for home or academic purposes.

6.CONCLUSION

6.1Key findings and outcomes

The Smart Herb Planter is an innovative, IoT-based solution that simplifies plant care by combining automation, sustainability, and smart control. Designed especially for urban users, it intelligently monitors temperature, humidity, soil moisture, and water levels using sensors like the DHT22, capacitive soil sensor, and JSN-SR04T ultrasonic sensor.

It automates plant care using:

- A motor pump via a 5V relay for soil moisture.
- A 100W bulb for warmth when temperature drops.
- A 24V mist maker to boost humidity.

All of this is controlled through a 2-channel relay and managed via a dual-mode system with Blynk IoT:

- Auto Mode: Full automation based on real-time data.
- Manual Mode: Remote control via the Blynk app.

A 1.3” OLED displays live readings, while Blynk shows data trends and enables control. The hardware is neatly enclosed in a 3D-printed case, making it compact, durable, and stylish for any space.

This project is more than just a herb planter—it's a glimpse into the future of smart gardening. With the growing need for self-sustained living and eco-friendly solutions, smart planters like this can play a vital role in urban agriculture, home automation, and STEM education.

The Smart Herb Planter brings together coding, electronics, design, IoT, and 3D printing, showing how interdisciplinary engineering can solve real-world problems in elegant and meaningful ways.

And this is just the beginning.

6.2 Potential improvements or future applications of the solution

The Smart Herb Planter is more than just a one-time project—it’s a glimpse into how technology can simplify our lives and strengthen our connection with nature. While the current system brings smart automation and convenience to plant care, there are many exciting directions this concept can evolve in the future.

1. **Solar Power Integration**
   By integrating solar panels, the entire system can run sustainably and independently, making it perfect for outdoor use like balconies and terraces, while also reducing reliance on electricity.

2. **AI-Driven Adaptability**
   Machine learning can make the planter even smarter—learning from seasonal patterns, user preferences, and plant behaviour to automatically adjust watering, heating, and humidity for optimal growth.

3. **Multi-Plant Support**
   Expanding the system to care for multiple plants with dedicated sensors and controls can transform it into a modular indoor garden. This is ideal for homes, classrooms, or small-scale urban agriculture.

4. **Enhanced User Interaction**
   Voice assistant integration and real-time push notifications could make the system even more interactive. Imagine being notified when the water tank is low or controlling the system through a simple voice command.

5. **Soil Health Monitoring**
   Future enhancements could include pH and nutrient sensors. With this data, the system could suggest fertilizing schedules—or even automate it—offering deeper insight into plant health.

6. **Advanced Analytics**
   An extended dashboard or web app could allow users to track long-term trends, compare data, and better understand plant behaviour. This would be especially useful for enthusiasts, researchers, or educators.

7. **Self-Refilling System**
   By connecting to a larger reservoir, the water tank could refill automatically based on ultrasonic level detection—minimizing user intervention and maximizing convenience.

8. **Community Sharing & Collaboration**
   Open-sourcing the design and code could foster a community of smart gardeners who share their own enhancements, plant profiles, and 3D-printed designs—encouraging creativity and shared growth.

This smart planter is just a small step toward a larger vision—where technology, sustainability, and everyday life blend seamlessly. With further development, it has the potential to revolutionize personal gardening, promote urban greenery, support education, and even contribute to global environmental efforts.

7.CONTRIBUTIONS

Nikhil V: I was actively involved throughout the Smart Herb Planter project, especially in both the design and technical implementation. I handled setting up the ESP32 microcontroller and connecting all the key sensors—DHT22 for temperature and humidity, the capacitive soil moisture sensor, and the JSN-SR04T for water level. I also configured the relays for controlling the pump, bulb, and humidifier. On the software side, I wrote and refined the entire Arduino code, added an OLED display using the U8g2lib, and integrated everything with the Blynk app, including Auto and Manual modes with virtual pin control. I helped design the 3D casing, planned out the layout for all components, and worked on making the user interface clear and easy to use. I also documented the process, helped test and debug the system, and made sure everything worked smoothly together. Overall, I contributed to creating a functional, reliable, and user-friendly smart planter.

Armaan S: As one of the initial team members, I proposed the idea of creating a Smart Herb Planter that uses automated watering and sensor integration to support home gardening. I was slightly involved in hardware development or coding, I participated in early-stage brainstorming sessions, helped define the overall project vision, and supported coordination among team members as the project progressed.

Guddanti Nikhil Srinivas: I was involved in the assembly of the Smart Herb Planter system, ensuring proper integration of sensors, relays, and the ESP32 microcontroller. Additionally, I assisted my peer Nikhil in troubleshooting and optimizing the circuit design using information derived from online communities and technical forums. Moreover, I created a PowerPoint presentation of the project which briefly summarized the technical aspects and illustrated the capability of the smart planter in operation.

Yashas Raj S A: I contributed significantly to the Smart Herb Planter project by Spending dedicated time working in the makerspace lab. Collaborating with my teammate Nikhil V on various aspects of the building. Assisting in assembling and testing the hardware components. Engaging in multiple iterations of trial and error to improve the design and performance of the system.

Vatam Hanvesh Reddy: I contributed to the Smart Herb Planter project by actively participating in brainstorming sessions and discussing the working and testing of the circuit with Yashas. I used online resources and forums to help troubleshoot issues and improve the system's functionality. My role focused on supporting the design logic ensure smooth integration of all components.

Poojari Karthikeyulu: I was involved in the assembly of the Smart Herb , uses and benefits of the smart herb planter and where it will grow safely with minimum budget and safety. And I study the connection of the circuit and I learnt about the product by staying in the makerspace.

8.REFERENCES

This project was guided by a range of resources including datasheets, library documentation, online tutorials, and research articles related to ESP32, sensors, relay control, Blynk IoT, and 3D printing. These references provided essential technical insights and inspired the design and functionality of the Smart Herb Planter.

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