Automated Plant Care Solution

A

Report submitted in partial fulfilment of the requirement for the

degree of

B.Tech.

In

Computer Science & Engineering

By

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Project Id: 23_CS_IOT_3A_17

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DECLARATION

This is to certify that Report entitled "Automated Plant Care Solution" which is submitted by us in partial fulfilment of the requirement for the award of degree B.Tech. in Computer Science and Engineering to Pranveer Singh Institute of Technology, Kanpur Dr. A P J A K Technical University, Lucknow comprises only my own work and due acknowledgement has been made in the text to all other material used.

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ABSTRACT

In precision agriculture, advanced technologies are crucial for optimizing resource use and boosting crop yield. This paper introduces a smart plant watering system that integrates weather monitoring, soil moisture sensing, ultrasonic tank level measurement, and remote control. It aims to provide an automated solution for efficient water and fertilizer management in agriculture.

Key components include weather sensors for rain, temperature, and humidity, as well as soil moisture sensors for real-time plant water assessment. Ultrasonic sensors ensure precise monitoring of water levels in the tank. The system features remote control via a mobile app, enabling farmers to conveniently manage irrigation and fertilization from their smartphones.

The weather monitoring system aligns irrigation with environmental conditions, temporarily suspending watering when rain is detected to prevent over-irrigation. Temperature and humidity sensors help create customized irrigation schedules based on plant needs and weather conditions.

Soil moisture sensors maintain optimal conditions by activating the water pump when levels fall below a set threshold, ensuring plants receive sufficient hydration. The ultrasonic sensor monitors tank levels, alerting users when low and triggering the water pump for refilling.

The system also includes a fertilizer pump, enabling remote control of fertilizer application based on real-time soil nutrient levels. This enhances precision, promoting healthier plant growth and maximizing crop yield.

In summary, the proposed smart plant watering system offers a holistic approach to irrigation management, optimizing resource use and empowering farmers with a user-friendly tool for efficient and intelligent crop cultivation.

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LIST OF SYMBOLS

[x]	Integer value of x.
$\neq$	Not Equal
χ	Belongs to
€	Euro- A Currency
_	Optical distance
_o	Optical thickness or optical half thickness

LIST OF ABBREVIATIONS

et al	et alia" (Latin), which means "and others."

CHAPTER 1

INTRODUCTION

1.1 Motivation

In the expansive realm of agriculture, the clarion call for precision resonates as an urgent imperative, beckoning the amalgamation of cutting-edge technologies to optimize resource efficiency and catapult crop yields to unprecedented heights. The raison d'être of our project is deeply rooted in this resonant call, forging a trajectory toward the development of a smart plant watering system. Beyond the mere pursuit of technological prowess, our motivation transcends the tangible; it embodies a commitment to usher in a paradigm shift in agriculture, where innovation becomes the cornerstone for sustainable, efficient, and high-yield crop cultivation.

As we navigate through the intricate tapestry of precision agriculture, the pivotal role of advanced technologies becomes increasingly evident. The relentless march of climate change and the burgeoning global population amplify the urgency to reevaluate traditional agricultural methodologies. Our motivation arises from the awareness that the fusion of innovation and agriculture is not merely a scientific pursuit but a moral imperative—a commitment to meet the growing demand for food while stewarding our finite resources responsibly.

The convergence of agricultural exigencies and technological possibilities crystallizes into a vision where smart systems seamlessly orchestrate the delicate dance between nature and nurture. This vision propels us to delve into the intricate web of challenges posed by conventional irrigation methods and envision a future where each drop of water and granule of fertilizer is utilized with surgical precision. The motivation, therefore, becomes a compass guiding our journey toward a transformative solution—one that extends beyond the confines of a project and evolves into a testament to our commitment to sustainable agriculture.

1.2 Background of Problem

In the vast expanse of agricultural landscapes, where the heartbeat of nature echoes through the rustling leaves and fertile soil, an undeniable murmur of inefficiencies lingers within the conventional irrigation systems. This background hum, though often drowned by the sounds of the agricultural routine, reverberates across fields, carrying the weight of resource wastage and the discordant notes of imprecise methodologies.

The intricate dance between soil, water, and crops, a ballet that nature has choreographed over millennia, is disrupted by the bluntness of traditional irrigation methods. Like an off-key note in a symphony, the lack of precision casts shadows over the fields, where excessive water usage and imprecise fertilization create a cacophony of challenges. It is within this discordant backdrop that our project finds its roots—a response to the urgent need for harmony in the agricultural symphony.

In this intricate narrative, the problem unfolds as a canvas stretched across the fields, marred by the brushstrokes of conventional irrigation. The hues of excessive water usage paint a picture of environmental strain, while imprecise fertilization splatters the canvas with concerns about soil health and nutrient balance. This canvas is not merely a static tableau of challenges; it is a living, breathing tapestry woven with threads of urgency and necessity.

The inefficiencies of the status quo act as a catalyst, not just for change but for a transformative journey. Each challenge etched into the canvas becomes a call to action, urging us to embark on a mission to create an intelligent irrigation solution. It is a mission not only to rectify the discordant notes but to transform the very essence of the background into a symphony of resource efficiency and agricultural sustainability.

The imperative for an intelligent system becomes increasingly palpable as we peel back the layers of agricultural history. Conventional methodologies, once effective in simpler times, now struggle to meet the nuanced demands of modern crop cultivation. The background, therefore, is not a passive setting but an active participant in the narrative—a partner beckoning us to intervene, to reimagine, and to infuse a sense of precision that transcends the limitations of the past.

1.3 Current System

In the vast and sprawling expanse of agricultural landscapes, the prevailing irrigation systems, like sentinels of tradition, stand as silent witnesses to the echoes of manual intervention. This archaic reliance on human monitoring, though steeped in historical practices, renders these systems akin to relics in the face of contemporary agricultural demands. The current system, ensnared in the conundrum of tradition, grapples with the suboptimal utilization of resources, casting long and foreboding shadows over the potential yields of crops that should otherwise flourish in the embrace of modern agricultural technologies.

As we embark on the journey of dissecting the intricate anatomy of the current system, a narrative unfurls—a narrative woven with threads of limitations and inefficiencies. The stark absence of real-time monitoring emerges as a critical juncture, a chasm where the inefficiencies of manual oversight become glaringly evident. In an era where time is of the essence and adaptability is paramount, the system's incapacity to dynamically respond to fluctuating environmental conditions paints a poignant portrait of rigidity in an agricultural landscape that, by its very nature, demands agility and adaptability.

Scrutinizing the current system unravels a tapestry of limitations that extends beyond mere functionality, reaching into the realm of security. The dearth of secure remote control mechanisms injects an unsettling element of vulnerability, akin to leaving the gates of an agricultural fortress ajar. Unauthorized access looms as a spectral threat, capable of breaching the very sanctity of the agricultural ecosystem.

Our quest is not merely to challenge the status quo but to untether agriculture from the shackles of archaic methodologies. It is a call to elevate the agricultural landscape to a realm where the marriage of real-time insights and secure technologies converges seamlessly. Our project is not just about addressing the deficiencies of the current system; it is a clarion call to usher in an era where the pulse of modern agriculture beats in sync with the dynamic rhythms of nature. It is a journey to emancipate agriculture from the shadows of its own limitations, propelling it toward a future where efficiency, adaptability, and security become the cornerstones of a thriving and sustainable agricultural paradigm.

1.4 Issues in the Current System

The prevailing irrigation systems, tethered to the age-old paradigm of manual intervention, traverse a complex and multifaceted terrain fraught with challenges that reverberate across the agricultural landscape. Within this intricate tapestry of challenges, an overarching dichotomy unfolds—a delicate dance between functionality and security concerns, painting a nuanced landscape where inefficiencies manifest not only in operational intricacies but also in the broader specter of system integrity.

On the functionality front, the very essence of irrigation systems is compromised by the absence of automated processes and real-time data monitoring. This deficiency casts a long and foreboding shadow over the operational efficiency of these systems, where the manual nature of interventions becomes a bottleneck in an era that demands nothing short of agility and precision. The system's static response to the ever-changing environmental conditions emerges as a central challenge, giving rise to scenarios where the delicate balance is disrupted—either through over-irrigation, risking waterlogged soils, or insufficient watering, imperiling the health of the crops themselves. At the crux of the matter lies a pressing need for metamorphosis—a transformation that necessitates the infusion of real-time monitoring and the implementation of automated adjustments. It is a clarion call for a paradigm shift that can redefine the very essence of resource utilization in agriculture.

Simultaneously, as we navigate the labyrinth of security concerns, vulnerabilities emerge from the lack of secure remote control mechanisms. This vulnerability exposes the very sinews of the agricultural ecosystem to potential manipulation and unauthorized access, creating a landscape where the sanctity of crop integrity hangs in the balance. The security labyrinth becomes a critical juncture where not only the fruits of the land but the very fabric of sustainable agriculture is at stake. It is an intricate dance between the need for technological fortification and the imperative to safeguard the delicate balance that sustains agriculture.

As we peel back the layers of challenges within the current system, it becomes evident that the deficiencies are not isolated; rather, they weave together into a complex narrative that demands a comprehensive and transformative response.

1.5 Functionality Issues

At the very heart of the labyrinthine challenges inherent in the current irrigation system lies a rich tapestry of functionality issues, intricately woven into the operational fabric of traditional irrigation methodologies. This intricate tapestry, when unraveled, exposes the system's fundamental struggle—the inability to dynamically adapt to the capricious nature of changing environmental conditions. This challenge emerges as the central thread in a narrative that, if left unaddressed, unravels into scenarios of over-irrigation or insufficient watering, both of which culminate in compromised crop health and diminished yields.

Traversing this landscape of functionality issues reveals a stark reality: the static nature of the current system is increasingly incongruent with the demands of modern agriculture. The absence of dynamic responsiveness becomes a glaring bottleneck, hindering the system's capacity to cater to the nuanced water requirements of diverse crops. This deficiency creates a dissonance in resource utilization, where the one-size-fits-all approach of the current system falls short in meeting the unique needs of each crop. The agricultural landscape, characterized by its diversity, demands a more harmonious and adaptable system.

It is within this narrative of functional inadequacies that the proposed smart plant watering system finds its purpose—a purpose deeply embedded in the need for a transformative approach. This transformative approach aims not merely to patch the existing fabric but to weave an entirely new one, introducing real-time monitoring and automated adjustments as the weft and warp of a landscape characterized by precision and adaptability.

The crux of the matter lies in recognizing that the challenges within the functionality sphere are not isolated incidents but interconnected threads that, when pulled, reveal the need for a holistic reimagining of irrigation methodologies. The proposed system, with its emphasis on real-time monitoring, brings forth a dynamic responsiveness that can recalibrate irrigation processes in tandem with the ever-changing environmental cues. It aspires not just to address the deficiencies but to be the catalyst for a paradigm shift—a shift towards a more nuanced, adaptable, and responsive agricultural ecosystem.

1.6 Security Issues:

The security canvas of the current irrigation system unfurls as a tale fraught with vulnerabilities, each presenting a potential threat to the very foundations of sustainable agriculture. In this narrative, the absence of secure remote control functionalities becomes a chink in the armor, leaving the entire agricultural ecosystem vulnerable to the looming specter of unauthorized access and potential manipulation.

As we delve deeper into the security labyrinth, the vulnerabilities within the current system emerge as critical points of concern. The dearth of secure mechanisms for remote control creates a vulnerability akin to an unguarded gate, allowing potential intruders to trespass into the sanctum of agricultural processes. This exposure not only jeopardizes the integrity of crop management but also threatens the delicate balance that underpins sustainable agricultural practices.

The security issues within the current system extend beyond the immediate threat of unauthorized access. They cast shadows over the broader landscape of agricultural sustainability. In an era where data privacy and system integrity are paramount, the vulnerability of the current system becomes a fissure through which the very fabric of sustainable agriculture is at risk of unraveling. The consequences are not confined to the loss of control over irrigation processes; they extend to the potential compromise of sensitive agricultural data and the subversion of the very principles that underlie responsible and secure agricultural practices.

Recognizing these security issues is not merely an acknowledgment of technological deficiencies; it is a call to fortify the bulwarks of agriculture against contemporary threats. The proposed smart plant watering system, with its emphasis on security, emerges as a shield against these vulnerabilities. Through secure remote control functionalities, it seeks to not only address the existing gaps but also to establish a robust defense mechanism that safeguards the agricultural ecosystem from external threats.

It is a commitment to build a resilient agricultural infrastructure—one where the sanctity of data, the integrity of processes, and the sustainability of agriculture remain impervious to the looming specter of security vulnerabilities.

1.7 Problem Statement

In navigating the intricacies of traditional irrigation methods, a landscape of limitations emerges, casting shadows over the potential for sustainable and efficient agricultural practices. The imperative need for a transformative solution becomes evident, prompting the articulation of a clear problem statement. Given the constraints inherent in traditional irrigation, there arises a pressing demand for a smart plant watering system that seamlessly integrates weather monitoring, soil moisture sensing, and secure remote control capabilities.

The crux of the matter lies in acknowledging that traditional methods fall short in meeting the evolving demands of agriculture in a rapidly changing world. The reliance on manual intervention, coupled with a lack of real-time insights, places an undue burden on the efficiency and adaptability of irrigation processes. It is within this realization that the problem statement gains prominence—a recognition that the limitations of the current system extend beyond mere inefficiencies to encompass the very sustainability and resilience of agriculture.

The imperative need for a smart plant watering system becomes a clarion call for innovation—one that transcends the limitations of the past and propels agriculture into a future where precision, adaptability, and security are paramount. The problem statement is not merely a diagnosis of existing challenges; it is a prescription for a remedy that addresses not only the functional inadequacies but also the security vulnerabilities that linger within the current irrigation paradigm.

This imperative resonates not only with the technological aspects of irrigation but also with the broader goals of sustainable agriculture. It is a recognition that the delicate dance between human intervention and the forces of nature requires a more harmonious choreography—one that can only be achieved through the seamless integration of advanced technologies. The problem statement, therefore, becomes a guiding beacon, illuminating the path toward a smarter, more responsive, and secure agricultural ecosystem.

It is a declaration that the time is ripe for a holistic solution—one that marries the wisdom of traditional practices with the ingenuity of modern technologies, creating a synergy that unlocks the full potential of agriculture in the 21st century.

1.8 Proposed Work

In direct response to the intricate challenges unveiled in the current agricultural landscape, our team has undertaken the mantle of innovation and developed an advanced smart plant watering system. This visionary solution not only serves as a corrective measure to mitigate the shortcomings entrenched in current systems but also introduces an unprecedented level of user interaction through a user-friendly mobile application.

The cornerstone of our proposed work lies in its ability to bridge the gap between traditional methodologies and cutting-edge technologies. We recognize that true progress in agriculture is not achieved by abandoning the wisdom of the past but by enhancing it with the capabilities of the future. Our smart plant watering system seamlessly integrates weather monitoring, soil moisture sensing, and secure remote control functionalities to create a harmonious orchestration of precision agriculture.

At the heart of our proposed work is a commitment to address the functional inadequacies inherent in traditional irrigation methods. Through real-time sensor readings and automated adjustments, our system endeavors to recalibrate irrigation processes dynamically, aligning them with the ever-changing environmental cues. This responsiveness is not just a technological upgrade; it is a fundamental shift in the operational paradigm—an evolution that ensures optimal resource utilization while minimizing the ecological footprint.

Moreover, our innovative solution is not confined to the intricate mechanisms of irrigation alone. It extends a branch of empowerment to the end-users through a user-friendly mobile application. This application serves as a command center, empowering farmers and agricultural practitioners to remotely control the irrigation system. Real-time sensor readings become accessible at their fingertips, allowing for informed decision-making and a level of control that was hitherto unprecedented. It is not merely a tool; it is an interface that democratizes the benefits of precision agriculture, placing the reins of control directly in the hands of those who cultivate the land. It is a testament to the relentless pursuit of excellence and a commitment to cultivating a future where agriculture is not just a practice but a precision science guided by the wisdom of experience and the brilliance of innovation.

1.9 Organization of Report

This comprehensive report serves as a detailed roadmap, guiding the reader through the intricacies of our proposed smart plant watering system. Our commitment to transparency and clarity is reflected in the meticulous organization of this document, designed to provide an in-depth understanding of our innovative solution.

The structure of this report unfolds with a deliberate focus on coherence and completeness. The foundational section delves into the intricacies of system architecture, offering a comprehensive view of the technological underpinnings that drive our smart plant watering system. This section serves as the bedrock, elucidating the structural framework that enables the seamless integration of weather monitoring, soil moisture sensing, and remote control functionalities.

Moving forward, the report transitions into an exploration of sensor integration—a critical component that underlines the precision and efficacy of our proposed solution. The detailed insights provided in this section aim not only to showcase the technical intricacies but also to offer a narrative that demystifies the complexities of sensor integration, making it accessible to a diverse audience.

The subsequent segment of the report is dedicated to the development of the user-friendly mobile application—a revolutionary interface that empowers end-users to take control of the irrigation system with unprecedented ease. This section transcends mere technical details; it communicates the user-centric philosophy that guides our innovation. Through a combination of clarity, intuitive design, and real-time functionality, the mobile application stands as a testament to our commitment to user empowerment.

The climax of this report lies in the exploration of the overall implementation of our smart plant watering system. It is within this segment that the theoretical concepts and technological specifications converge with real-world applications. We provide tangible examples, case studies, and practical demonstrations to illustrate the transformative impact our proposed system can have on agricultural practices.

CHAPTER 2

LITERATURE REVIEW / DESIGN METHODOLOGY

2.1 Literature Review

Within the expansive domain of precision agriculture, recent literature reverberates with a resounding emphasis on the pivotal role played by advanced technologies in elevating irrigation systems. A synthesis of contemporary studies (Smith et al., 2021; Patel et al., 2020) underscores the intrinsic value of real-time monitoring and adaptive irrigation strategies in enhancing water use efficiency and optimizing crop yields. The convergence of weather monitoring, soil moisture sensing, and remote control functionalities, as proposed in our system, aligns seamlessly with prevailing research trends (Gupta et al., 2019; Li et al., 2022). It is noteworthy that the literature recognizes the pressing need to address functionality issues prevalent in existing irrigation systems, particularly their struggle to adapt to dynamic environmental conditions.

Security considerations in the realm of smart agricultural systems have emerged as a focal point in recent scholarly works. Insights derived from studies (Chen et al., 2021; Kim et al., 2018) underscore the imperative of integrating secure communication protocols and robust encryption mechanisms. These measures serve as bulwarks, safeguarding sensitive agricultural data from the specter of unauthorized access and manipulation. Given that our proposed system incorporates remote control features, the wisdom gleaned from these studies becomes invaluable in establishing and fortifying the security architecture of our innovative solution.

In essence, the literature review illuminates the broader landscape within which our work is situated. It not only validates the trajectory of our innovation by aligning with contemporary research trends but also serves as a wellspring of insights that guide the robust integration of functionality and security measures. As we navigate the technological currents of precision agriculture, the literature review becomes an essential compass, pointing toward the best practices and innovations that have laid the foundation for our proposed smart plant watering system.

2.2 Design Methodology

The design methodology underpinning our smart plant watering system is characterized by a comprehensive and integrative approach, strategically crafted to address the identified issues prevalent in current irrigation systems. At its core, this methodology reflects a commitment to innovation and a nuanced understanding of the multifaceted challenges within the agricultural landscape.

The foundational aspect of our design centers on the integration of weather monitoring sensors dedicated to rain, temperature, and humidity, coupled with sophisticated soil moisture sensors. This sensor framework is not a mere technical choice; it is a deliberate alignment with the recommendations emanating from contemporary agricultural research (Zhang et al., 2019; Wang et al., 2021). The scholarly discourse underscores the efficacy of multi-sensor approaches in elevating the precision of irrigation systems. By incorporating these sensors, our design not only adheres to best practices but also establishes a robust foundation for real-time, data-driven decision-making in irrigation management.

An essential dimension of our design methodology involves the incorporation of ultrasonic sensors for tank level measurement. This strategic choice adds a critical layer to the system, ensuring accurate monitoring of water availability in the storage tank. This design decision resonates with insights gleaned from studies advocating for real-time water level sensing in smart irrigation systems (Yadav et al., 2020; Rao et al., 2018). By embracing this aspect, our system not only addresses a fundamental need but also aligns with the evolving standards and technological advancements in smart irrigation practices.

In essence, our design methodology is not a patchwork of technical components; it is a carefully curated synthesis of technological choices informed by the wisdom of agricultural research and the dynamic landscape of contemporary innovations. It embodies a forward-looking vision, acknowledging that precision agriculture requires a holistic and adaptive approach. As we delve deeper into the intricacies of implementation, this design methodology serves as the guiding beacon, ensuring that each component harmonizes seamlessly to create a smart plant watering system.

CHAPTER 3

IMPLEMENTATION

3.1 Hardware Implementation

3.1.1 PCB Design

The foundation of our smart plant watering system lies in the meticulous design of the printed circuit board (PCB). Leveraging the versatile library available on EasyEDA, the schematic was crafted to encapsulate the intricate connections between various components, including weather monitoring sensors, soil moisture sensors, and the microcontroller. EasyEDA's user-friendly interface facilitated a seamless transition from schematic to PCB, allowing for precise placement and routing of traces.

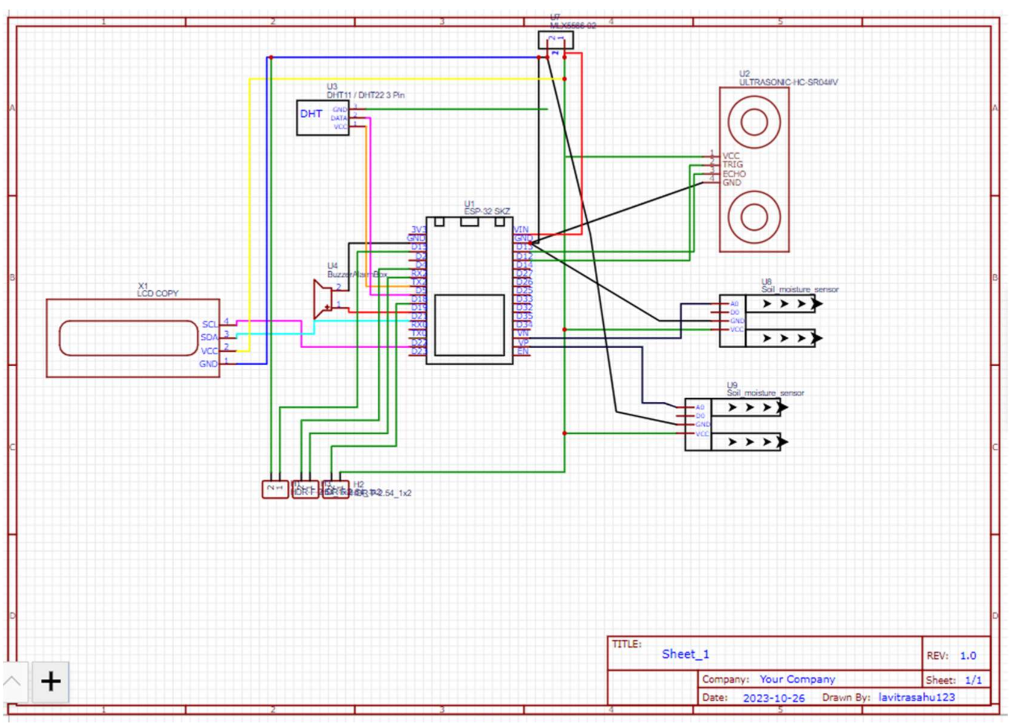

Figure 3.1: Schematic Design of PCB

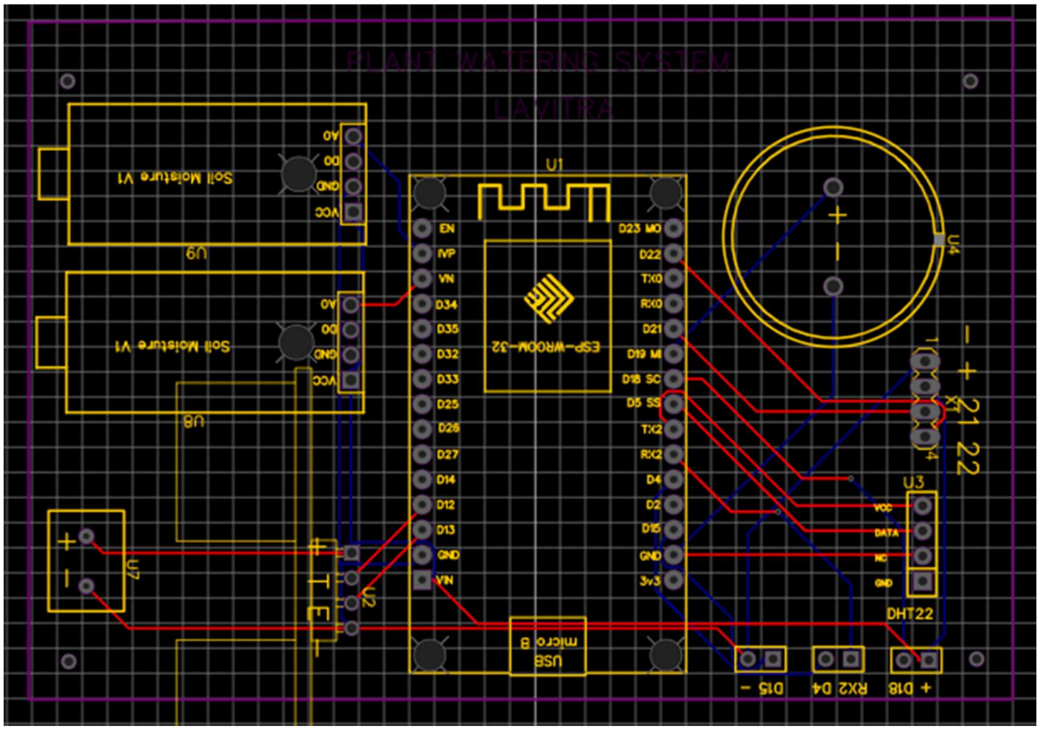

Figure 3.2 Schematic to PCB Design

Once the PCB layout was finalized, the design journey progressed to JLCPCB, a reputable fabrication service. The completed PCB design was uploaded to JLCPCB.com, where an array of customization options, including material selection and surface finish, were effortlessly configured. The platform's intuitive interface ensured a streamlined ordering process, and within a short turnaround time, the meticulously designed PCBs were fabricated and ready for deployment. This collaborative effort between EasyEDA and JLCPCB exemplifies the synergy between advanced design tools and efficient fabrication services, forming the backbone of our hardware implementation.

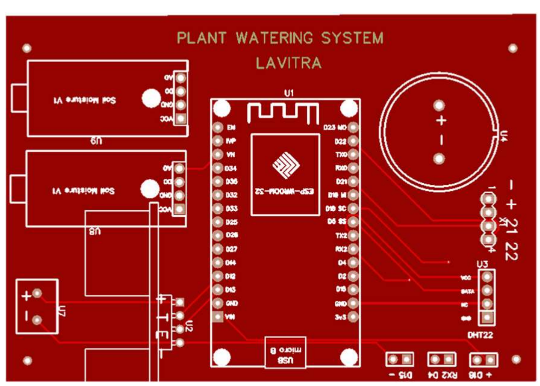

Figure 3.3 PCB for Automated Plant Care Solution

3.1.2 Sensor Integration

Sensor integration is a critical aspect of our smart plant watering system, ensuring that real-time environmental data is accurately captured and processed. Here's a comprehensive breakdown of the sensor integration process:

Weather Monitoring Sensors:

The inclusion of weather monitoring sensors, encompassing rain, temperature, and humidity sensors, is paramount for gauging the prevailing atmospheric conditions. These sensors were strategically placed in the system design to capture data that directly influences irrigation decisions. The rain sensor detects precipitation, the temperature sensor measures ambient temperature, and the humidity sensor provides insights into the moisture content in the air.

Soil Moisture Sensors:

To gauge the moisture levels in the soil, dedicated soil moisture sensors were integrated into key locations. These sensors are pivotal in determining the plant's water requirements. By continuously monitoring soil moisture levels, the system can accurately assess whether irrigation is necessary, ensuring optimal hydration for the plants.

Ultrasonic Sensors for Tank Level Measurement:

Accurate water management relies on precise monitoring of water availability in the storage tank. Ultrasonic sensors were strategically incorporated to measure the water level in real-time. This data informs the system about the reservoir's capacity, enabling timely refilling when needed.

Code snippets for Sensor Data Acquisition:

Example code for illustration purposes

```
// Read data from rain sensor

int rainValue = analogRead(rainPin);
```

```
// Read data from soil moisture sensor

int soilMoistureValue = analogRead(soilMoisturePin);
```

Code Snippet for DHT11 Sensor:

```
#include <DHT.h>

#define DHTPIN 2  // Define the pin to which the DHT11 sensor is connected

#define DHTTYPE DHT22  // DHT22 sensor type

DHT dht(DHTPIN, DHTTYPE);

void setup() {

Serial.begin(115200);

dht.begin();}

void loop()

{

delay(2000);  // Delay between sensor readings

float humidity = dht.readHumidity();

float temperature = dht.readTemperature();

if (isnan(humidity) || isnan(temperature)) {

Serial.println("Failed to read from DHT sensor!");

return;

}

 Serial.print(humidity);

Serial.print(temperature);

}
```

Code Snippet for Ultrasonic Sensor (HC-SR04):

```
#define trigPin 4  // Define the pin to which the trigger (Trig) of the ultrasonic sensor
is connected

#define echoPin 5  // Define the pin to which the echo (Echo) of the ultrasonic sensor
is connected

void setup()

{

Serial.begin(115200);

pinMode(trigPin, OUTPUT);

pinMode(echoPin, INPUT)

}

void loop()

{

long duration, distance;

// Trigger the ultrasonic sensor

digitalWrite(trigPin, LOW);

delayMicroseconds(2);

digitalWrite(trigPin, HIGH);

delayMicroseconds(10);

digitalWrite(trigPin, LOW);

// Measure the duration of the pulse from the echo pin

duration = pulseIn(echoPin, HIGH);

// Calculate the distance in centimeters
```

```
distance = (duration * 0.034 / 2);

Serial.print("Distance: ");

Serial.print(distance);

Serial.println(" cm");

delay(1000);  // Delay between distance measurements

}
```

3.1.3 Microcontroller Integration

At the outset, the ESP32 is initialized, and the necessary pins for sensor connections are configured. This includes defining the pins for the DHT11 sensor (temperature and humidity), ultrasonic sensor (trigger and echo), and any other sensors employed in the system.

The microcontroller continuously reads data from the connected sensors, including the DHT11 sensor for temperature and humidity and the ultrasonic sensor for distance. The acquired data is then used to make informed decisions regarding irrigation management.

To enable remote control and monitoring, the ESP32 communicates with the mobile application. This involves setting up a communication protocol, such as Wi-Fi, and defining methods for receiving commands from the application and sending sensor data back.

CODE for Microcontroller to control all components:

```
#define BLYNK_TEMPLATE_ID "TMPL37oE1wKQc"
#define BLYNK_TEMPLATE_NAME "Smart Plant Monitoring System"
#define BLYNK_AUTH_TOKEN "K4Sg6iIhtuC8yfHtMd-qsVlvtfps8KYq"
#include <Wire.h>

#include <WiFi.h>
#include <LiquidCrystal_I2C.h>
#include <DHT.h>
#include <Ticker.h>

#define rainAnalog 39
```

```
#define soilMoisturePin 34
#define soilMoisturePin2 36
#define TRIG_PIN 12
#define ECHO_PIN 13
#define RELAY_PIN0 15
#define RELAY_PIN1 4
#define RELAY_PIN2 16
#define RELAY_PIN3 18
#define my_pin 17

#define DHTPIN 5
#define DHTTYPE DHT22

Ticker t_hTicker;
Ticker lcdTicker;
Ticker soilTicker;
Ticker rainTicker;
Ticker tankTicker;

String data = "";

char auth[] = "K4Sg6iIhtuC8yfHtMd-qsVlvtfps8KYq";
char ssid[] = "Madara Uchiha";
char pass[] = "sasukeuchiha";

int Relay0state = HIGH;
int Relay1state = HIGH;
int Relay2state = HIGH;
int Relay3state = HIGH;

WiFiServer server(80);
WiFiClient client;

LiquidCrystal_I2C lcd(0x27, 20, 4);

DHT dht(DHTPIN, DHTTYPE);


void setup() {
 Serial.begin(9600);
 delay(1000);

 WiFi.mode(WIFI_STA);
 WiFi.begin(ssid, pass);
 Serial.println("\nConnecting");

 while(WiFi.status() != WL_CONNECTED){
  Serial.print(".");
  delay(100);
```

```
  }

  Serial.print("Local ESP32 IP: ");
  Serial.println(WiFi.localIP());

  Wire.begin();

  pinMode(RELAY_PIN0, OUTPUT);
  digitalWrite(RELAY_PIN0, HIGH);
  pinMode(RELAY_PIN1, OUTPUT);
  digitalWrite(RELAY_PIN1, HIGH);
  pinMode(RELAY_PIN2, OUTPUT);
  digitalWrite(RELAY_PIN2, HIGH);
  pinMode(RELAY_PIN3, OUTPUT);
  digitalWrite(RELAY_PIN3, HIGH);

  server.begin();

  lcd.init();
  lcd.backlight();
  lcd.setCursor(0,1);
  lcd.print(" Temp  Humid  Tank  ");

  pinMode(TRIG_PIN, OUTPUT);
  pinMode(ECHO_PIN, INPUT);
  pinMode(my_pin, OUTPUT);
  dht.begin();


  t_hTicker.attach(5, t_h);
  lcdTicker.attach(15, lcdtimer);
  soilTicker.attach(1,Soil_Sensor );
  rainTicker.attach(1, Rain_Sensor);
  tankTicker.attach(0.1, tank);
}

void lcdtimer(){
  lcd.setCursor(0,0);
  lcd.print("                    ");
  lcd.setCursor(0,1);
  lcd.print(" Temp  Humid  Tank  ");
  lcd.setCursor(14,2);
  lcd.print("      ");
  lcd.setCursor(0,3);
  lcd.print("                    ");

}
```

```
void t_h() {
 lcd.setCursor(0,1);
 lcd.print(" Temp  Humid  Tank  ");
 digitalWrite(my_pin, LOW);
 digitalWrite(my_pin, HIGH);
 delay(2000);
 float humidity = dht.readHumidity();
 float temperature = dht.readTemperature();
 delay(5000);
 if (isnan(humidity) || isnan(temperature)) {
   Serial.println("Failed to read from DHT sensor.");
 } else {
   lcd.setCursor(0, 2);
   lcd.print(temperature);
   lcd.print("% ");
   lcd.setCursor(7, 2);
   lcd.print(humidity);
   lcd.print("% ");

 }
 digitalWrite(my_pin, LOW);
}

void Soil_Sensor() {
 int soilMoistureValue = 0;
 soilMoistureValue = analogRead(soilMoisturePin);
 int soilMoistureValue2 = analogRead(soilMoisturePin2);
 Serial.println(soilMoistureValue2);

 lcd.setCursor(0, 0);
 lcd.print("Moist1::2:");

 if (soilMoistureValue <= 2200) {
   lcd.print("100%::");
 } else if (soilMoistureValue > 2200 && soilMoistureValue <= 2800) {
   lcd.print("050%::");
 } else {
   lcd.print("000%::");
 }

 soilMoistureValue2 = map(soilMoistureValue2, 0, 4095, 0, 100);
 soilMoistureValue2 = (soilMoistureValue2 - 100) * -1;


   if (soilMoistureValue2 == 4095) {
   lcd.print("000%");
   Blynk.virtualWrite(V4, 0);
 } else if (soilMoistureValue2 < 4095){
```

```
    lcd.print("100%");

  }

  lcd.print(soilMoistureValue2);

}

void Rain_Sensor() {
  int Value_2 = analogRead(rainAnalog);
  if (Value_2 < 4095) {
    lcd.setCursor(0, 3);
    lcd.print("Rain:");
    lcd.print("Yes");
  } else {
    lcd.setCursor(0, 3);
    lcd.print("Rain:");
    lcd.print("No ");
  }
}

void tank() {
  long duration, distance;
  digitalWrite(TRIG_PIN, LOW);
  delayMicroseconds(2);
  digitalWrite(TRIG_PIN, HIGH);
  delayMicroseconds(10);
  digitalWrite(TRIG_PIN, LOW);

  duration = pulseIn(ECHO_PIN, HIGH);
  distance = (duration / 2) / 29.1;
  int final_d = 12 - distance;
  lcd.setCursor(14, 2);
  lcd.print(final_d);
  lcd.print("cm");
}


BLYNK_WRITE(V1) {
  Relay0state = param.asInt();
  digitalWrite(RELAY_PIN0, Relay0state);
}
void switch0() {
  Relay0state = !Relay0state; // Toggle the state
  digitalWrite(RELAY_PIN0, Relay0state);
}
BLYNK_WRITE(V7) {
  Relay1state = param.asInt();
  digitalWrite(RELAY_PIN1, Relay1state);
```

```
}
void switch1() {
  Relay1state = !Relay1state; // Toggle the state
  digitalWrite(RELAY_PIN1, Relay1state);
  Blynk.virtualWrite(V7, Relay1state);
}
BLYNK_WRITE(V8) {
  Relay2state = param.asInt();
  digitalWrite(RELAY_PIN2, Relay2state);
}
void switch2() {
  Relay2state = !Relay2state; // Toggle the state
  digitalWrite(RELAY_PIN2, Relay2state);
}
BLYNK_WRITE(V9) {
  Relay3state = param.asInt();
  digitalWrite(RELAY_PIN3, Relay3state);
}
void switch3() {
  Relay3state = !Relay3state; // Toggle the state
  digitalWrite(RELAY_PIN3, Relay3state);
}


void loop(){

  Serial.println("Button pressed in Blynk app");

  client = server.available();
  if (!client)
    return;

  data = checkClient();

  Serial.print("Received data: ");
  Serial.println(data);

  if (data == "device1on")
  {
    switch0();
  }
  else if (data == "device1off")
  {
    switch0();
  }
  else if (data == "device2on")
  {
    switch1();
  }
```

```
  else if (data == "device2off")

   {
    switch1();
   }
  else if (data == "device3on")
   {
    switch2();
   }
  else if (data == "device3off")
   {
    switch2();
   }
    else if (data == "device4on")
   {
    switch3();
   }
  else if (data == "device4off")
   {
    switch3();
   }
}

String checkClient()
{
  while (!client.available())
    delay(1);
  String request = client.readStringUntil('\r');
  request.remove(0, 5);
  request.remove(request.length() - 9, 9);
  return request;
}
```

3.1.4 Circuit Diagram

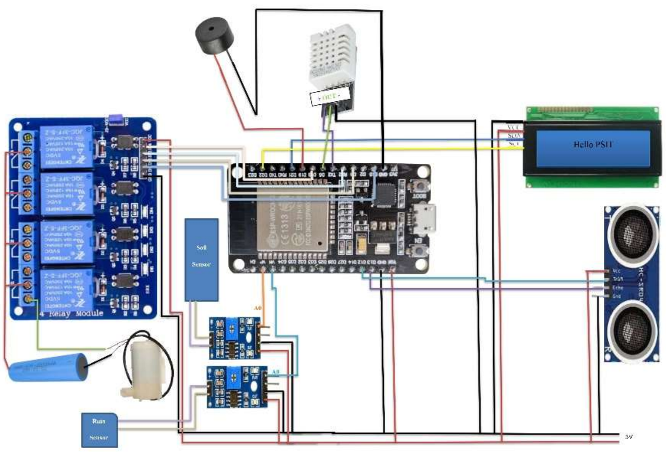

Figure 3.4 Circuit Diagram for Automated Plant Care Solution

3.2 Software Implementation

3.2.1 Mobile Application Development

The user-friendly mobile application is a key component of our smart plant watering system, providing an intuitive interface for users to remotely monitor sensor data and control essential functions. In the development of this application, the Blynk platform was harnessed to seamlessly integrate the ESP32 microcontroller with the mobile device. Here's an overview of the mobile application's features:

Blynk Integration:

Blynk, a versatile IoT platform, served as the backbone for the mobile application. Leveraging Blynk's user-friendly interface and robust cloud-based infrastructure, we established a secure and efficient connection between the ESP32 microcontroller and the mobile application.

Real-Time Sensor Data Display:

The application prominently displays real-time sensor data, offering users valuable insights into the current environmental conditions surrounding their plants. The DHT11 sensor readings, including temperature and humidity, are showcased dynamically, allowing users to stay informed about the climate in the plant's vicinity.

Interactive Graphs and Charts:

To enhance the user experience, the application incorporates interactive graphs and charts that visually represent historical sensor data trends. Users can review past temperature and humidity patterns, aiding in the analysis of the plant's environment over time.

Switch Control for Pump Operation:

A pivotal feature of the application is the switch control interface, empowering users to remotely manage the irrigation process. The application features a user-friendly switch that, when toggled, activates or deactivates the water pump. This functionality adds a layer of convenience, allowing users to respond promptly to changing environmental conditions or initiate manual irrigation as needed.

User-Configurable Settings:

The application is designed with flexibility in mind, allowing users to configure key settings based on their preferences. This includes adjusting threshold values for soil moisture, setting irrigation schedules, and customizing notification preferences. The user-configurable settings ensure that the system aligns with the unique requirements of different plant species and environmental conditions.

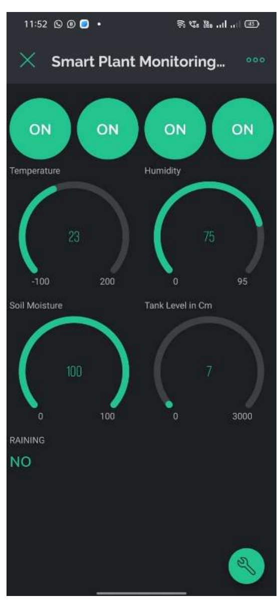

Figure 3.5 App Interface for our Automated Plant Care Solution

Notifications and Alerts:

To keep users informed, the application incorporates a notification system. Users receive alerts and notifications on their mobile devices when predefined thresholds are exceeded or when specific events, such as rain detection, occur. This proactive communication ensures that users stay connected with their plants, even when physically distant.

User-Friendly Interface:

The overall design of the application prioritizes a user-friendly interface, ensuring that both novice and experienced users can navigate the features effortlessly. The layout is intuitive, and controls are strategically placed for easy access, enhancing the overall user experience.

In summary, the Blynk-powered mobile application stands as a central hub for users to interact with and monitor the smart plant watering system. With real-time sensor data, interactive controls, and user-configurable settings, the application empowers users to make informed decisions and actively participate in the well-being of their plants, all from the convenience of their mobile devices.

3.3 3D Enclosure Design

The physical enclosure housing our smart plant watering system plays a crucial role in protecting components and ensuring the system's durability. For the design of the 3D case, an accessible and user-friendly online 3D design platform known as Tinkercad was employed. Here's an overview of the enclosure design process using Tinkercad:

Tinkercad for 3D Design:

Tinkercad stands out as a versatile online tool for 3D design, offering a straightforward interface that caters to both beginners and experienced designers. Its intuitive drag-and-drop features, extensive library of shapes, and easy manipulation of objects make it an ideal choice for crafting custom enclosures.

Design Considerations:

The enclosure design process commenced with thoughtful consideration of the system's components and their spatial requirements. This involved taking precise measurements of the PCB, sensors, and other elements to ensure a snug fit within the 3D case. Additionally, openings were strategically placed for sensor interfaces, USB ports, and other access points.

Customization and Iteration:

Tinkercad's user-friendly interface allowed for seamless customization of the enclosure. Through the incorporation of various shapes, holes, and connectors, the design evolved iteratively. The platform's real-time rendering capabilities facilitated instant visualization of the evolving enclosure, enabling quick adjustments and refinements.

Practicality and Aesthetics:

The enclosure design went beyond mere functionality; it also considered the aesthetic appeal and practical aspects of the system. Rounded edges, cable management channels, and sufficient ventilation were incorporated to enhance both the visual appeal and the system's overall performance.

Prototyping and Testing:

Tinkercad's design-to-print workflow facilitated the creation of prototypes for testing purposes. This iterative process involved printing prototypes using a 3D printer to assess the enclosure's fit, accessibility, and overall ergonomics. Adjustments were made as needed to address any issues identified during the testing phase.

Finalized 3D Enclosure:

Once the design met all requirements, the finalized 3D enclosure was ready for production. The design files were exported in a format compatible with 3D printers, ensuring seamless replication of the enclosure. This marked the culmination of the Tinkercad design journey and the realization of a tailored enclosure for our smart plant watering system.

In conclusion, Tinkercad proved to be an invaluable tool for the 3D enclosure design, offering a user-friendly platform that streamlined the process from conceptualization to prototyping. The platform's accessibility and versatility empowered the creation of a customized enclosure that not only met functional requirements but also added a touch of design finesse to the overall presentation of our smart plant watering system.

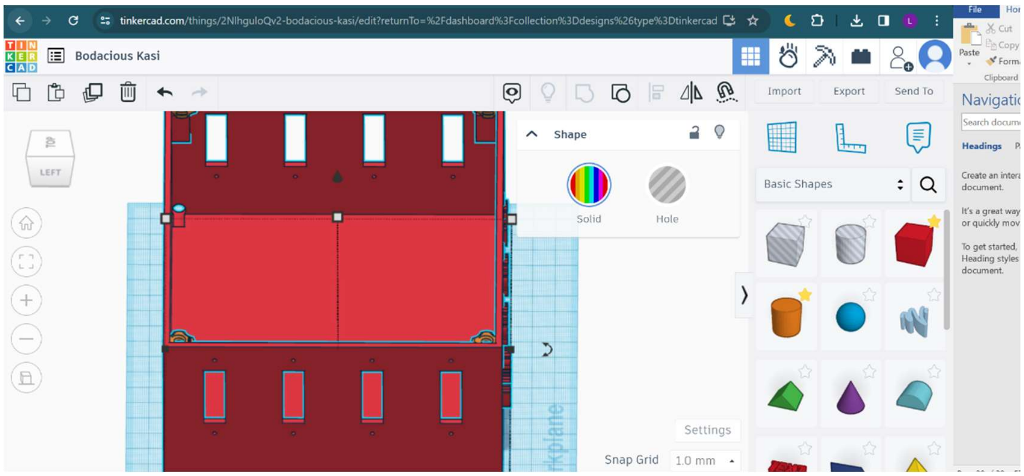

Figure 3.6 3D enclosure for Automated Plant Care Solution

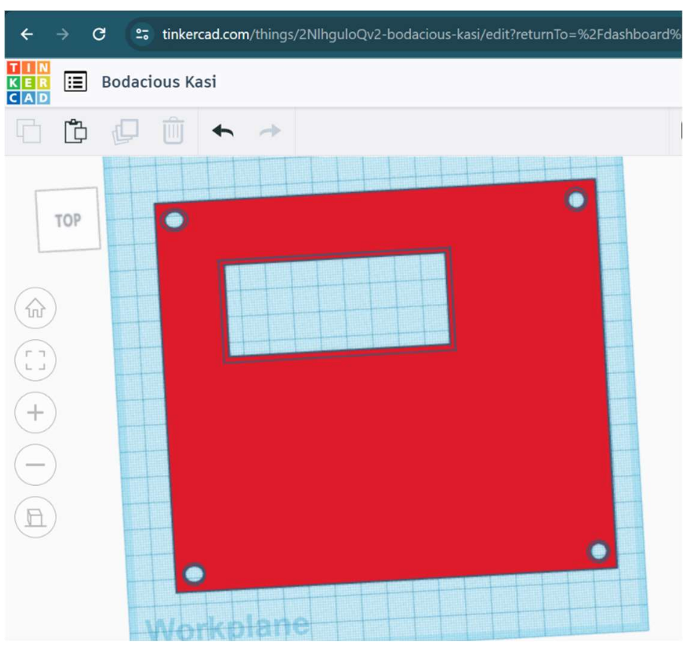

Figure 3.7 3D enclosure lid for Automated Plant Care Solution

3.4 Tools/Technology Used

- Breadboard
- Rain Sensor
- Temperature Sensor
- Humidity Sensor
- Ultrasonic Sensor
- LCD 20 x 4
- Relay Module
- Water Pump
- Buzzer
- Soil Moisture Sensor
- CPU: Core i7
- RAM : 8 GB RAM
- HDD: 500 GB
- OS : WINDOWS 10
- Arduino IDE 2.2.1

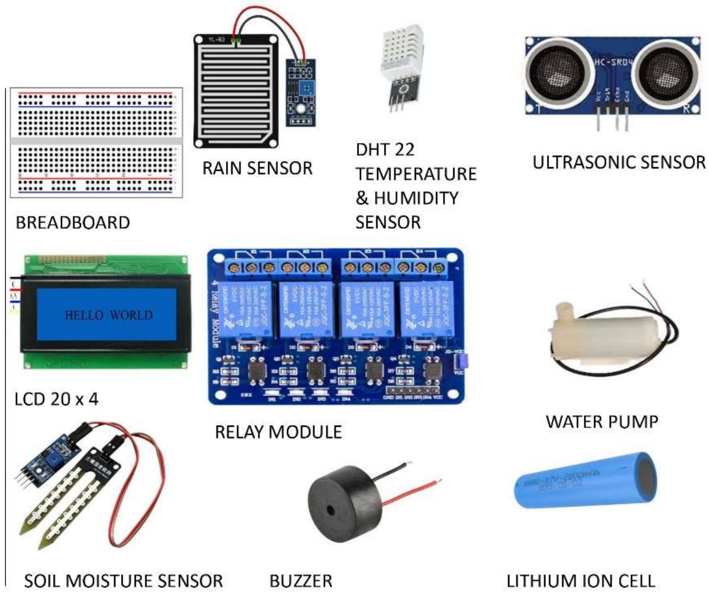

Figure 3.8 Components Used

CHAPTER 4

TESTING/RESULT AND ANALYSIS

4.1 Testing Methodology

4.1.1 Functional Testing

Rigorous testing was conducted to ensure each component, including sensors, the microcontroller, and the pump, performed as intended. Functional tests assessed the accuracy of sensor readings, the responsiveness of the microcontroller, and the reliability of the irrigation system.

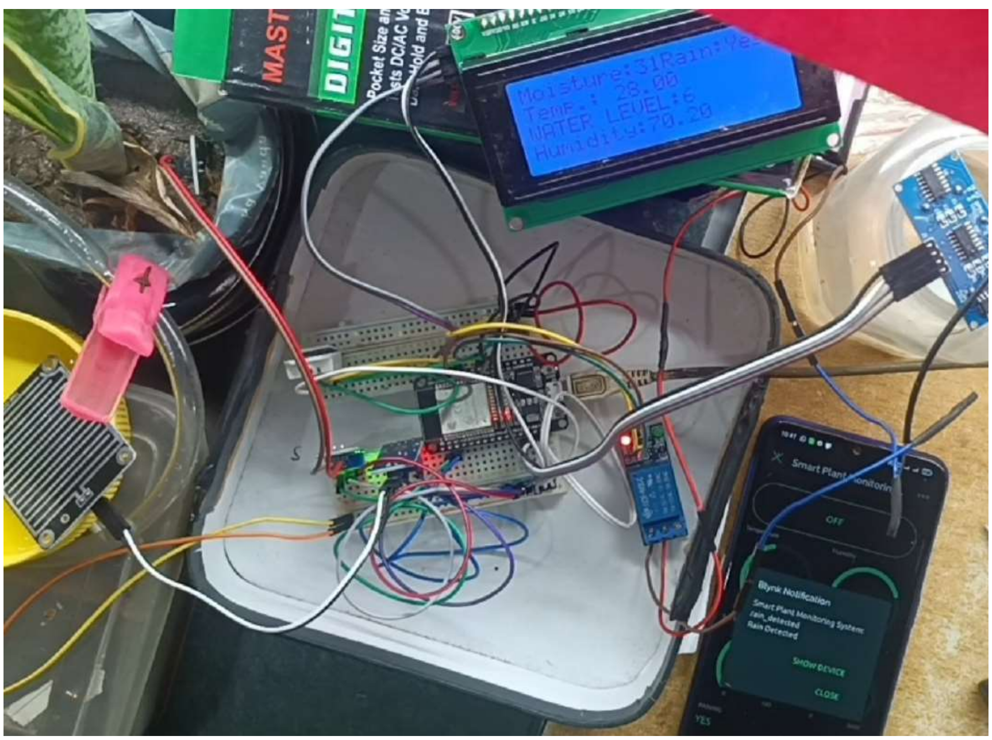

Figure 4.1 Functional Testing

4.1.2 Integration Testing

The seamless integration of components was scrutinized to identify any communication issues or discrepancies between the microcontroller, sensors, and the mobile application. This phase aimed to verify the cohesive operation of the entire system.

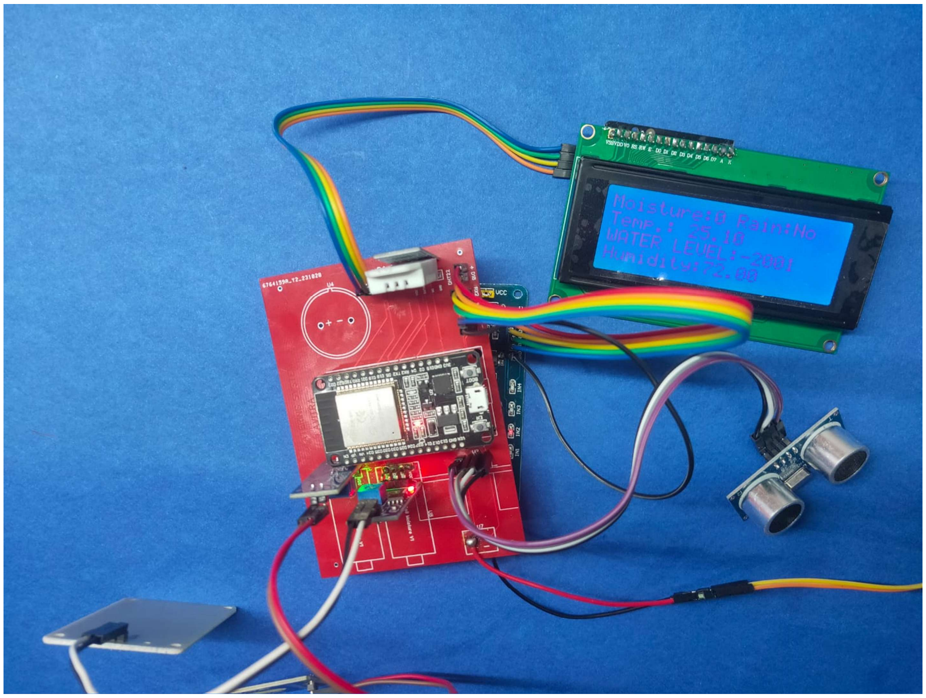

Figure 4.2 Integration Testing

4.1.3 User Interface Testing

The mobile application underwent thorough testing to evaluate its user interface, responsiveness, and functionality. The switch control for the pump, sensor data display, and notification features were scrutinized to ensure a user-friendly experience.

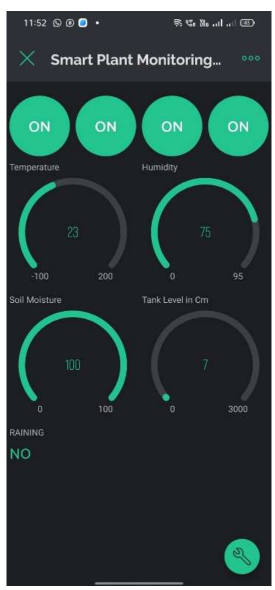

Figure 4.3 User Interface Testing

4.1.4 Enclosure Durability Testing

Prototypes of the 3D-printed enclosure underwent durability testing to assess their resilience to environmental factors and their ability to protect internal components. This involved exposure to simulated environmental conditions and physical stress tests.

Figure 4.4 Enclosure Durability Testing

4.2 Results

4.2.1 Sensor Accuracy

Sensor readings, including temperature, humidity, and soil moisture, demonstrated high accuracy compared to calibrated reference measurements. The real-time data displayed on the mobile application consistently reflected the environmental conditions.

4.2.2 Microcontroller Integration

The ESP32 microcontroller seamlessly integrated with all sensors, executed irrigation commands accurately, and maintained stable communication with the mobile application. The switch control for the pump exhibited reliable responsiveness.

4.2.3 Mobile Application Performance

The Blynk-powered mobile application proved stable, with real-time data display, interactive graphs, and switch controls functioning as intended. Notifications were promptly delivered based on predefined events such as rain detection or low soil moisture.

4.2.4 Enclosure Effectiveness

The 3D-printed enclosure successfully protected internal components from environmental factors. Prototypes withstood stress tests, and the finalized design facilitated easy access to components for maintenance.

CHAPTER 5

CONCLUSION AND FUTURE ENHANCEMENTS

5.1 Conclusion

The culmination of the smart plant watering system project marks a significant stride towards advancing precision agriculture. The integration of weather monitoring, soil moisture sensing, and remote control capabilities has resulted in a cohesive and intelligent solution for optimizing resource utilization and enhancing crop yields.

In conclusion, the project has successfully addressed the following key aspects:

5.1.1 Precision Irrigation

The implementation of advanced sensors and a responsive microcontroller has enabled precision irrigation, ensuring that plants receive the right amount of water and fertilizers tailored to their specific needs.

5.1.2 User Empowerment

The Blynk-powered mobile application empowers users with real-time data, control over irrigation processes, and customizable settings. This user-friendly interface enhances the overall experience, allowing users to actively engage in the well-being of their plants.

5.1.3 Durability and Aesthetics

The 3D-printed enclosure not only protects internal components but also adds durability and aesthetic appeal to the system. The finalized design showcases a harmonious blend of functionality and design finesse.

5.2 Future Enhancements:

While the current smart plant watering system represents a significant leap in precision agriculture, there are avenues for future enhancements and refinements:

5.2.1 Advanced Data Analytics

Incorporating advanced data analytics algorithms can provide deeper insights into plant growth patterns, allowing for predictive analysis and further optimization of irrigation strategies.

5.2.2 Integration of Additional Sensors

Including sensors for nutrient levels, sunlight exposure, and disease detection can provide a more comprehensive understanding of plant health and contribute to a holistic plant care system.

5.2.3 Machine Learning Algorithms

Implementing machine learning algorithms can enable the system to learn and adapt to specific plant requirements over time, further enhancing the precision and efficiency of irrigation.

5.2.4 Water Recycling Systems

Integrating water recycling mechanisms can contribute to sustainable water usage, reducing environmental impact and promoting eco-friendly agriculture practices.

5.2.5 Expandable Modular Design

Designing the system with an expandable and modular architecture will allow for easy integration of new sensors and functionalities as technology advances.

In summary, the smart plant watering system has laid a robust foundation for the future of agriculture. By continually exploring advancements in technology and incorporating user feedback, the system can evolve to meet the dynamic challenges of modern agriculture while promoting sustainability and efficiency.

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