B20 L4S1

IN4300 – Embedded Systems

Project Report

Project Title:

Automated Plant Watering System

Group No: **01**

Group Name: **AquaBotics**

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2025

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Chapter 01 – Introduction

1.1 Background & Motivation

Plants are fundamental to our ecosystem and play a vital role in sustaining life. From the food we consume to the air we breathe, plants are indispensable. Whether in agriculture, horticulture, or even home gardening, ensuring the healthy growth of plants is paramount. Water, being a critical resource for plant survival, needs to be managed effectively. Traditional manual watering methods, while common, often present challenges. These methods can be time-consuming, require consistent physical effort, and are prone to inconsistencies, leading to either overwatering or underwatering, both of which can negatively impact plant health and yield.

In recent years, the rise of the Internet of Things (IoT) has paved the way for innovative solutions across various sectors, including agriculture and home automation. Smart agriculture and automated gardening systems are gaining traction as they offer the potential to optimize resource utilization and enhance efficiency. This project, the "Automated Plant Watering System," is motivated by the need to address the limitations of manual watering by leveraging IoT technologies to create a smart, efficient, and remotely manageable plant care solution. By integrating technology into plant care, we aim to simplify the process, conserve resources, and ultimately promote healthier plant growth.

1.2 Problem in Brief

The core problem this project addresses is the inefficiency and potential for error inherent in manual plant watering. Inconsistent watering schedules and volumes can lead to significant plant stress, reduced growth, and even plant loss. Furthermore, manual watering can be labour-intensive, especially for individuals managing larger gardens or multiple plant sections. There is a clear need for a system that can automatically and precisely manage plant hydration, ensuring optimal soil moisture levels are maintained without constant human intervention. This project seeks to develop a solution that not only automates the watering process but also allows for remote monitoring, providing a more reliable and convenient approach to plant care.

1.3 Scope of the Project

This project focuses on designing and implementing an Automated Plant Watering System utilizing the ESP8266 microcontroller, high-quality non-corrosive soil moisture sensors, and relay modules. The system is engineered to monitor soil moisture in two distinct sections, each managed by individual motors, thereby enabling tailored irrigation based on specific moisture requirements. Additionally, the incorporation of Wi-Fi connectivity facilitates remote monitoring and control, allowing users to oversee and adjust irrigation parameters via a dedicated application or web interface.

It is important to note that the scope of this project is centred on the automation of the watering mechanism and remote monitoring. While the system is designed to be adaptable for various plant types, the project's current phase will not delve into plant-specific watering algorithms or extensive data analytics. Furthermore, this project is intended as a prototype and does not encompass aspects of commercialization or large-scale agricultural applications.

1.4 Significance of the Project

The implementation of this Automated Plant Watering System offers several significant benefits:

- **Water Conservation**: By delivering water only, when necessary, the system minimizes wastage, contributing to more sustainable water usage.
- **Enhanced Plant Health**: Consistent and optimal watering schedules promote healthier plant growth and potentially higher yields.
- **Labor Efficiency**: Automation reduces the need for manual monitoring and watering, freeing up time for other essential tasks.
- **Scalability**: The modular design allows for easy expansion to accommodate additional sections or different plant types with varying moisture needs.
- **Remote Accessibility**: Real-time monitoring and control capabilities enable users to manage their irrigation systems from anywhere, providing flexibility and convenience.

In summary, this project aims to harness IoT technology to develop a reliable, efficient, and user-friendly automated irrigation system that addresses common challenges in plant care and resource management.

Chapter 02 – Aim & Objectives

2.1 Aim

The primary aim of this project is to develop an Automated Plant Watering System that utilizes the ESP8266 microcontroller, high-quality non-corrosive soil moisture sensors, and relay modules to autonomously manage irrigation. The system will monitor soil moisture levels in two distinct sections, each controlled by individual motors, and provide remote monitoring capabilities through Wi-Fi connectivity.

2.2 Objectives

To achieve the stated aim, the project encompasses the following specific objectives:

- **Design and Development**: Engineer a robust system architecture incorporating the ESP8266 microcontroller, reliable non-corrosive soil moisture sensors, and relay modules to facilitate automated irrigation.
- **Sectional Irrigation Control**: Implement dual motor control to manage two separate sections, allowing for tailored watering schedules based on the unique moisture requirements of each area.
- **Remote Monitoring and Control**: Integrate Wi-Fi connectivity to enable users to remotely monitor soil moisture levels and control irrigation parameters via a user-friendly application or web interface.
- **System Calibration and Testing**: Conduct comprehensive calibration of sensors and actuators, followed by rigorous testing to ensure system accuracy, reliability, and responsiveness under various environmental conditions.
- **User Education and Documentation**: Develop detailed user manuals and provide training resources to facilitate seamless system adoption and operation by end-users.

Chapter 03 – System Description

3.1 Introduction

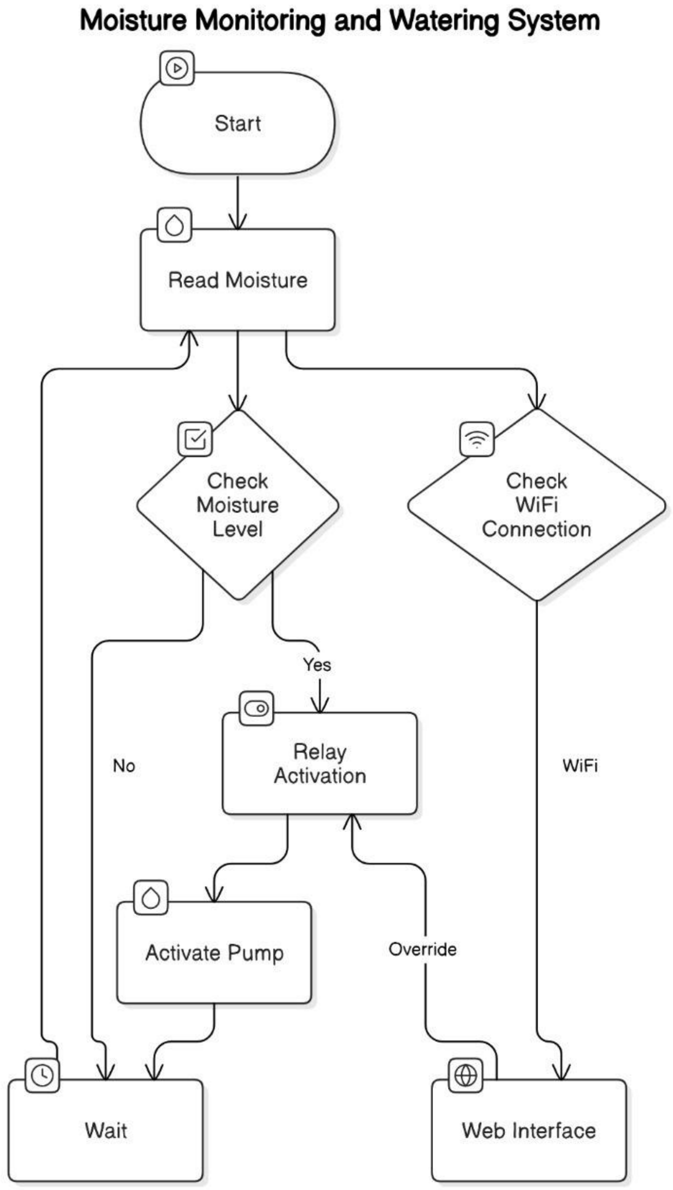
The Automated Plant Watering System is designed to autonomously manage irrigation by monitoring soil moisture levels and controlling water delivery accordingly. Leveraging the ESP8266 microcontroller, the system integrates high-quality, non-corrosive soil moisture sensors and relay modules to ensure efficient and reliable operation. This chapter provides a comprehensive overview of the system's components, workflow, and key functionalities.

3.2 System Components

The primary components of the Automated Plant Watering System include:

- **ESP8266 Microcontroller**: A Wi-Fi-enabled microcontroller that serves as the system's central processing unit, facilitating data acquisition, processing, and communication.
- **Soil Moisture Sensors**: High-quality capacitive sensors that detect soil moisture levels. Unlike resistive sensors, capacitive sensors are less prone to corrosion, ensuring longevity and consistent performance. citeturn0search5
- **Relay Modules**: Electromechanical switches that control the activation of water pumps based on signals received from the ESP8266, enabling automated irrigation.
- **Water Pumps**: Two pumps responsible for delivering water to two distinct sections, allowing for targeted irrigation based on the specific moisture requirements of each area.
- **Power Supply**: A stable power source to ensure uninterrupted operation of the ESP8266, sensors, relays, and pumps.

3.3 System Workflow



The operational workflow of the system is as follows:

1. **Data Acquisition**: Soil moisture sensors continuously monitor the moisture content in each section and transmit analog signals corresponding to the detected levels.
2. **Data Processing**: The ESP8266 microcontroller reads the analog signals from the sensors, converts them into digital values, and compares them against predefined moisture thresholds.
3. **Decision Making**: If the soil moisture in a section falls below the set threshold, the ESP8266 activates the corresponding relay module.
4. **Irrigation Control**: The activated relay triggers the water pump to supply water to the specific section until the soil moisture reaches the desired level.

5. **Remote Monitoring**: Through Wi-Fi connectivity, the ESP8266 sends real-time soil moisture data and system status to a cloud platform, enabling users to monitor and control the system remotely via a web interface or mobile application.

3.4 Key Functionalities of the System

The Automated Plant Watering System offers several essential functionalities:

- **Automated Irrigation**: The system autonomously manages watering schedules based on real-time soil moisture data, ensuring plants receive optimal hydration without manual intervention.
- **Sectional Control**: With two independent water pumps, the system can cater to different moisture requirements in separate sections, allowing for customized irrigation strategies.
- **Remote Monitoring and Control**: Users can access real-time data and control the system remotely, adjusting settings or manually overriding operations as needed through a user-friendly interface.
- **Scalability**: The modular design allows for easy expansion, enabling additional sections and sensors to be incorporated to accommodate larger areas or diverse plant species.

Chapter 04 – Testing and Implementation

4.1 Hardware Implementation

The hardware implementation of the Automated Plant Watering System involves the integration of various components to achieve efficient and reliable operation.

4.1.1 Component Selection

- **ESP8266 Microcontroller**: Chosen for its Wi-Fi capabilities and sufficient GPIO pins, the ESP8266 serves as the central control unit, managing sensor data processing and actuator control.
- **Soil Moisture Sensors**: Capacitive soil moisture sensors are selected due to their resistance to corrosion, ensuring longevity and consistent performance.
- **Relay Modules**: Employed to interface the ESP8266 with the water pumps, relay modules allow for safe and effective control of high-power devices.
- **Water Pumps**: Two DC water pumps are utilized to irrigate separate sections, enabling targeted watering based on individual soil moisture readings.

4.1.2 Circuit Design

The system's circuit design ensures seamless communication between components:

- **Power Supply**: A regulated 5V power source supplies the ESP8266 and sensors, while a separate 12V supply powers the water pumps, ensuring adequate and stable operation.
- **Sensor Connections**: Each soil moisture sensor is connected to an analog input pin on the ESP8266, facilitating continuous monitoring of soil conditions.
- **Relay and Pump Connections**: The relay modules are connected to digital output pins on the ESP8266. When activated, the relays complete the circuit for the corresponding water pumps, initiating irrigation.

4.1.3 Assembly

The assembly process involves:

- **Mounting Components**: Securely positioning the ESP8266, sensors, relays, and pumps within a protective enclosure to shield against environmental factors.
- **Wiring**: Establishing reliable electrical connections between components, ensuring proper insulation and adherence to safety standards.
- **Testing Connections**: Verifying the integrity of all connections through continuity testing and initial power application, ensuring the absence of short circuits or faulty wiring.

4.2 Software Implementation Details

The software component is pivotal for system functionality, encompassing sensor data acquisition, decision-making algorithms, and communication protocols.

4.2.1 Programming Environment

- **Platform**: The Arduino Integrated Development Environment (IDE) is utilized for coding and uploading firmware to the ESP8266, owing to its user-friendly interface and extensive library support.
- **Libraries**: Essential libraries include the ESP8266WiFi library for network connectivity and the Blynk library for remote monitoring and control.

4.2.2 Firmware Development

- **Sensor Data Acquisition**: The ESP8266 reads analog signals from the soil moisture sensors, converting them into digital values representing moisture levels.
- **Decision-Making Algorithm**: The firmware incorporates a control algorithm that compares real-time moisture readings against predefined thresholds. If the moisture level in a section falls below the threshold, the corresponding relay is activated to initiate watering.
- **Wi-Fi Connectivity**: The ESP8266 connects to a specified Wi-Fi network, enabling data transmission to the Blynk platform for remote monitoring.
- **Remote Control Integration**: Through the Blynk application, users can monitor real-time soil moisture levels and manually control the irrigation system if necessary.

4.2.3 Code Deployment

- **Uploading Firmware**: The developed code is uploaded to the ESP8266 via a USB-to-serial interface, with careful attention to correct board selection and port configuration within the Arduino IDE.
- **Initial Testing**: Post-deployment, the system undergoes testing to ensure accurate sensor readings, reliable Wi-Fi connectivity, and proper relay operation in response to varying soil moisture levels.

4.3 Implementation Plan

The implementation plan outlines a structured approach to system development:

1. **Requirement Analysis**: Identifying system objectives, component specifications, and user requirements.
2. **Component Procurement**: Sourcing high-quality hardware components, including the ESP8266, capacitive soil moisture sensors, relays, and water pumps.

3. **Hardware Assembly**: Constructing the physical system based on the designed circuit, ensuring robust and safe assembly.
4. **Software Development**: Writing and testing firmware to facilitate sensor data processing, decision-making, and communication functionalities.
5. **System Integration**: Combining hardware and software components, followed by comprehensive testing to validate overall system performance.
6. **Deployment and Monitoring**: Installing the system in the designated environment, with ongoing monitoring to assess functionality and address any arising issues.

4.4 Challenges and Solutions

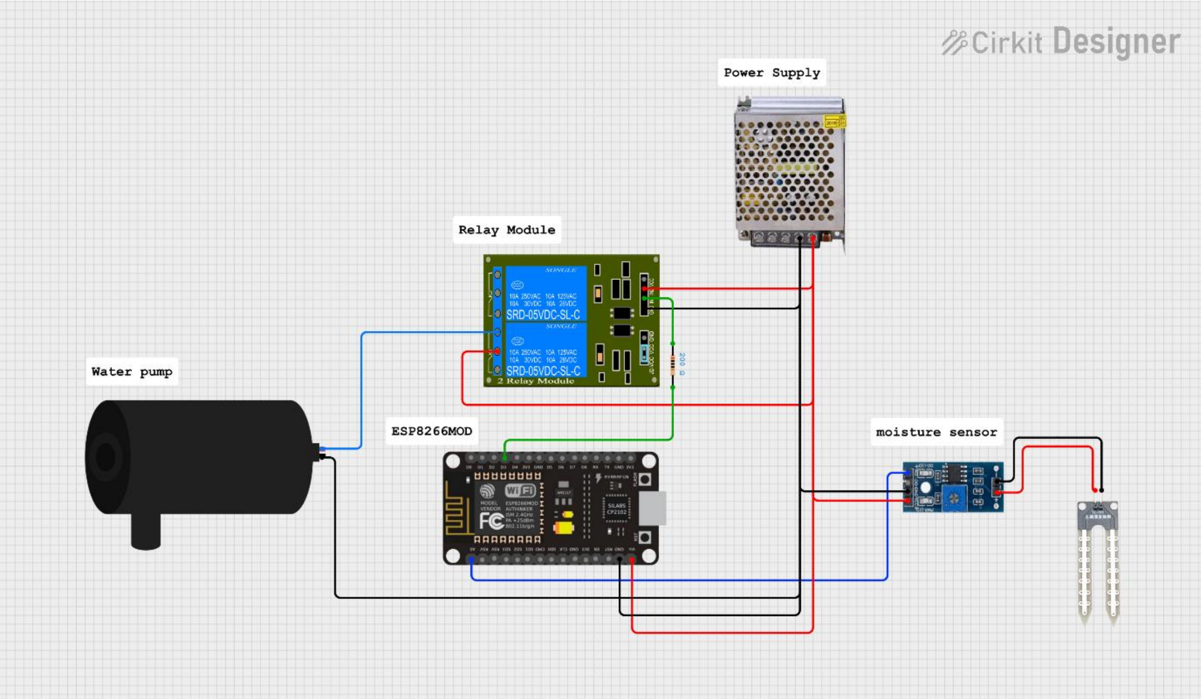
During the development and implementation phases, several challenges were encountered:

- **Wi-Fi Connectivity Issues**: Intermittent network connections were resolved by optimizing the ESP8266's power supply and implementing reconnection protocols within the firmware.
- **Sensor Calibration**: Variations in sensor readings necessitated calibration procedures to establish accurate moisture level thresholds tailored to specific soil types.
- **Power Management**: Ensuring sufficient and stable power for all components involved incorporating voltage regulators and selecting power supplies with appropriate current ratings.
- **Environmental Protection**: To safeguard electronic components from moisture and dust, enclosures with appropriate ingress protection ratings were employed.

Chapter 05 – Cost & Expenditure

Component	**Quantity**	**Unit Cost (LKR)**	**Total Cost (LKR)**
NodeMcu ESP8266 (CH340G) Development Board	1	700.00	700.00
Soil Moisture Sensor	1	200.00	200.00
SYB-120 / MB-102 Breadboard	1	400.00	400.00
Relay Module 5v	1	230.00	230.00
9V Battery	1	200.00	200.00
9V Battery Clip	1	50.00	50.00
DC 5V Micro Submersible Mini Water Pump	1	200.00	200.00
Mini Water Pipe	1	200.00	200.00
Male to Male Jumper Wire		160.00	160.00
Male to Female Jumper Wire		160.00	160.00

Circuit Diagram



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