CYBER-PHYSICAL SYSTEM FINAL PROJECT REPORT
DEPARTMENT OF ELECTRICAL ENGINEERING
UNIVERSITAS INDONESIA

Automatic Plant Watering System

GROUP 14

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PREFACE

In an era where technology permeates every aspect of our lives, from communication to transportation, it is only fitting that we extend these advancements to maintain our natural environment. This report delves into the development and implementation of an automatic plant watering system, a project that embodies the intersection of innovation of sustainability.

Our motivation behind this project is rooted in the growing need to optimize resource usage and enhance plant care efficiency. Traditional plant watering methods, while effective, can often lead to water wastage and require significant human intervention. In contrast, an automatic plant watering system leverages sensors like DHT11 and YL39, microcontrollers such as Arduino Uno ATmega328p, and assembly algorithms to ensure that plants receive the precise amount of water they need.

The purpose of this report is to examine some of the challenges related to agriculture and present our solution to these problems while adhering to the requirements set forth by Digilab Lab Assistant. We will also demonstrate the implementation of our solutions and the testing and evaluation that have been conducted.

This report provides a comprehensive overview of the project inception, design, execution phases. Furthermore, the report includes a thorough analysis of the system performance based on experimental data. The potential for scalability and future improvements is also explored.

We would like to extend our gratitude to our lecturer, F. Astha Ekadiyanto S.T, M.Sc., for all the guidance provided. We also wish to thank the Lab Assistant from Digilab for giving us this valuable opportunity to apply what we have learned in creating this project.

As you navigate through this report, we hope that you gain a deeper appreciation for the intricate blend of technology and nature, and how innovative solutions like the automatic plant watering system can contribute to a more sustainable and efficient future.

Depok, May 26, 2024

Group 14

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1 PROBLEM STATEMENT

The increasing demand for water conservation has highlighted the inefficiencies in traditional plant watering methods, particularly in residential settings [1]. Manual watering often leads to significant water wastage due to overwatering, inconsistent watering schedules, and human error. This not only results in higher water bills but also contributes to the depletion of valuable water resources. There is a critical need for a more efficient and sustainable solution to manage the watering of household plants, ensuring they receive the right amount of water at the right time, while minimizing water usage and maximizing conservation efforts.

1.2 PROPOSED SOLUTION

To address the issue of water wastage in traditional plant watering methods, we propose the implementation of an automatic plant watering system. This system utilizes smart technology to optimize the watering process, ensuring that household plants receive the precise amount of water they need, thereby conserving water and reducing waste.

This system includes soil moisture sensors to monitor the soil's condition in real time, ensuring that watering only occurs when necessary. A central control unit using Arduino Uno that processes data from these sensors to determine the optimal watering schedule, considering the specific needs of different plant types. Automated water pump, connected to the control unit, deliver water directly to the plants based on the moisture data, preventing overwatering and ensuring efficient water use.

By implementing this automatic plant watering system, households can achieve significant water savings, reduce their environmental footprint, and maintain healthy plants with minimal effort, promoting sustainable living practices and enhancing the efficiency of residential gardening.

1.3 ACCEPTANCE CRITERIA

The acceptance criteria of this project are as follows:

1. The system must be able to detect the soil condition such as humidity and temperature using DHT11 and soil moisture sensors.
2. The system must be able to show the soil condition such as humidity and temperature using MAX7219 and its integrated display.
3. The system must be able to indicate the dryness of the soil using a LED lamp.
4. The system must be able to control the water pump based on the soil condition.

1.4 ROLES AND RESPONSIBILITIES

The roles and responsibilities assigned to the group members are as follows:

Roles	Responsibilities	Person
Code Developer Schematic Designer Report Writer	- Writing the MAX7219 subroutine for each soil condition - Writing the DHT11 subroutine to display in LCD - Designing the circuit schematic in Proteus - Writing README and final project report - Collaborate with the group to assemble the circuit.	Christopher Satya Fredella Balakosa
Developer Designer	- Helping in designing the schematic in Proteus	Rafli Adithia

	- Debugging the code for the overall system - Giving input on the workability of the system	
Tester Report Writer Procurement Person	- Testing the physical form of the circuit - Collaborate with the group to check for error and reassembly - Writing the final project report - Purchasing materials and tools needed for the project	Darmawan Hanif
Assembler Procurement Person	- Assembling Physical Equipment - Troubleshooting Physical Equipment - Purchasing Necessary Materials for the project - Helping write the final project report	Aria Bima Sakti

Table 1. Roles and Responsibilities

1.5 TIMELINE AND MILESTONES

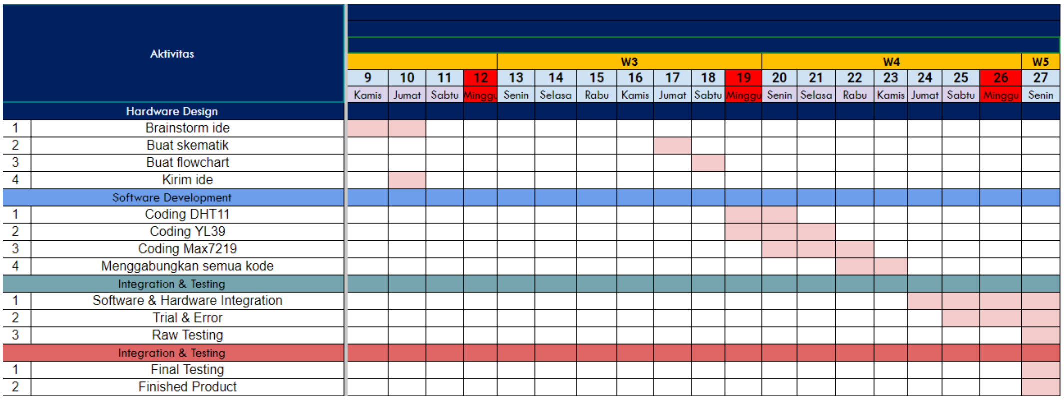
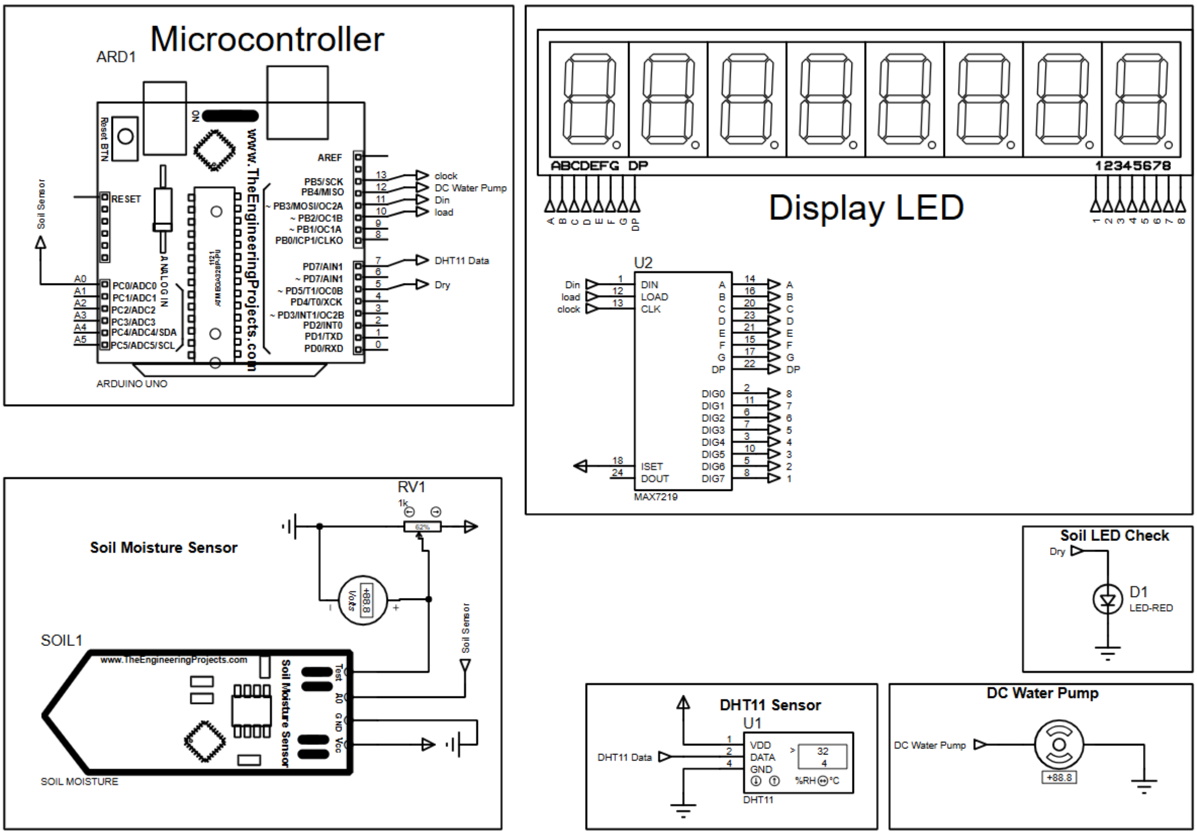


Fig. 1.1 Project Timeline in Gantt Chart

CHAPTER 2

IMPLEMENTATION

a. 2.1 HARDWARE DESIGN AND SCHEMATIC



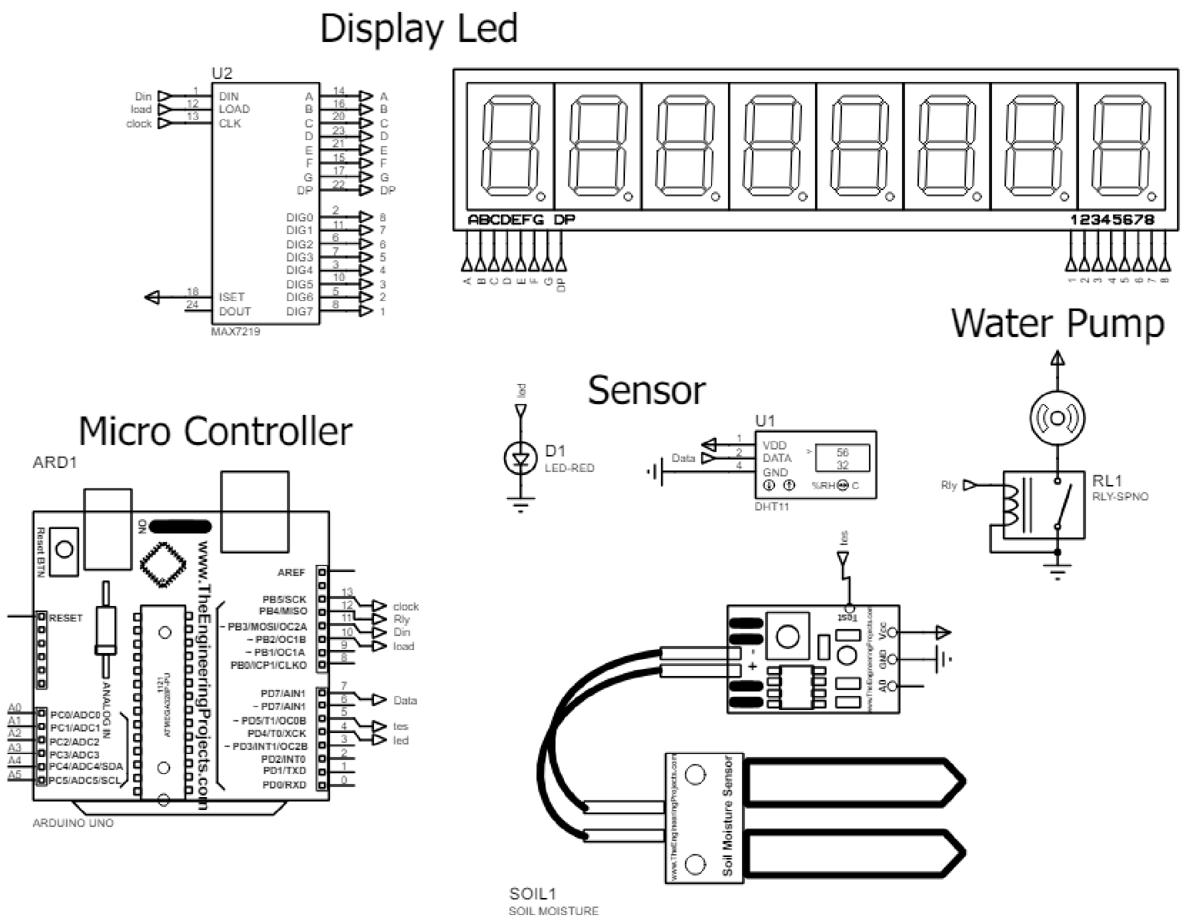


Fig. 2.1 Hardware Schematic

The hardware design for the automatic plant watering system utilizes the Arduino Uno microcontroller as the central hub, integrating various sensors and actuators to ensure efficient and controlled watering of household plants. The primary components include the YL-39 soil moisture sensor, the DHT11 temperature and humidity sensor, a 5V DC water pump, and an 8-digit seven-segment display.

The YL-39 soil moisture sensor consists of a probe and a module. The probe is inserted into the soil to measure moisture levels, and the module processes the signal from the probe. The analog output of the module is connected to pin PD5 on the Arduino Uno. This setup allows the sensor to measure the soil's moisture level and send an analog signal to the Arduino, which translates this signal into a moisture level value.

The DHT11 temperature and humidity sensor has three pins: VCC, GND, and Data. The VCC is connected to the 5V pin on the Arduino, GND to the ground pin, and the Data pin to pin PD7 on the Arduino Uno. This sensor measures the ambient temperature and humidity, providing additional data that can be used to optimize watering conditions.

The 5V DC water pump requires a separate power supply using a battery and a transistor to be controlled by the Arduino. The pump is connected to the battery through the collector and emitter of the transistor, with the base of the transistor connected to a digital output pin PB4 on the Arduino through a current-limiting resistor. The Arduino activates the transistor to allow current to flow through the pump, turning it on or off based on the soil moisture readings.

The 8-digit seven-segment display is integrated with the MAX7219. The module is connected to PB2, PB3, and PB5 pins in the Arduino. This display shows humidity, temperature, and if the soil is dry or already moist.

b. 2.2 SOFTWARE DEVELOPMENT

The assembly software written for this project integrates multiple sensors and a display to monitor and manage the watering process. The primary sensors include a DHT11 for temperature and humidity measurements and a YL-39 for soil moisture detection. The system uses a MAX7219-driven 8-digit seven-segment display to show sensor readings and status messages.

The program begins by setting up the necessary configurations and initializing the SPI communication for the MAX7219 display. This initialization includes setting data direction registers and enabling specific pins required for SPI communication. Once the setup is complete, the system enters the main loop where it continuously monitors sensor readings.

In the main loop, the system first prepares the DHT11 sensor by sending appropriate signals to initiate communication. It then waits for the sensor's response and reads the temperature and humidity data bit by bit. This process involves waiting for specific signals from the sensor and capturing the data into registers. After obtaining the raw sensor data, it is converted from binary to decimal format for easy interpretation.

The system then displays the temperature and humidity readings on the seven-segment display. This is done by sending the processed data through the SPI communication to the MAX7219, which updates the display accordingly. This provides real-time feedback on environmental conditions, ensuring users are informed about the current temperature and humidity.

In addition to monitoring temperature and humidity, the system also checks soil moisture levels using the YL-39 sensor. Depending on the moisture level detected, the system updates the display to show whether the soil is "MOIST" or "DRY." If the soil is detected as dry, a counter is incremented, and a red LED is turned on to alert the user. This feature ensures that the plant receives water when needed, preventing both overwatering and underwatering.

The program includes various delay functions to manage timing for sensor readings and display updates. These delays ensure that the sensors have enough time to stabilize and provide accurate readings, while also pacing the display updates to prevent flickering and provide clear information.

The display control is managed by setting appropriate commands and data for the MAX7219 driver. This involves configuring the display settings such as intensity, decoding mode, scan limit, and power state. The system updates the display to show specific text messages based on the sensor readings, ensuring that the user can easily understand the current status of the environment and soil moisture.

The following is a flowchart for the software we made:

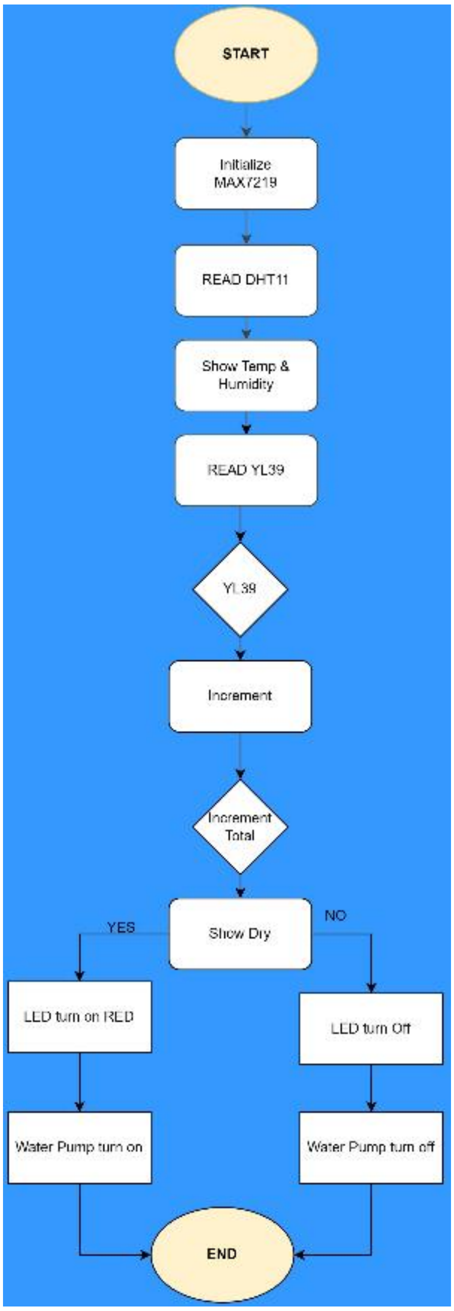


Fig. 2.2 Assembly Code Flowchart

c. 2.3 HARDWARE AND SOFTWARE INTEGRATION

For hardware integration and operation, ensure that the Arduino, sensors, and water pump have a stable power supply. The Arduino can be powered via USB or an external power source. The soil moisture sensor and DHT11 sensor continuously collect data and send it to the Arduino for processing. The Arduino then processes the data to determine if the soil moisture level is below a predefined threshold. If the soil is dry, the Arduino activates the transistor to power the water pump. The water pump waters the plants until the soil moisture sensor detects sufficient moisture, at which point the Arduino turns off the pump. The seven-segment display shows the current soil moisture level, temperature, and humidity, allowing users to monitor the system's status.

Overall, the assembly code creates an efficient and reliable automatic plant watering system. By integrating multiple sensors and a display, it provides comprehensive monitoring and management of plant watering needs. The real-time feedback and automated alerts help maintain optimal soil moisture levels, promoting healthy plant growth and efficient water use.

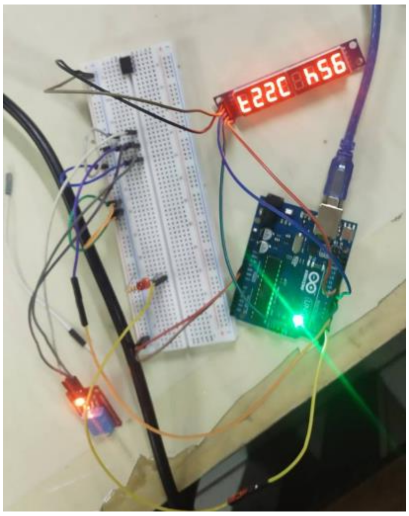


Fig. 2.3 Physical Implementation

CHAPTER 3

TESTING AND EVALUATION

d. 3.1 TESTING

Testing phase for our automatic plant watering system was designed to evaluate the functionality, reliability, and efficiency of both hardware and software components. The testing was conducted in a controlled environment to simulate various soil moisture conditions and ambient environmental factors.

The Arduino Uno microcontroller, sensors, and the water pump were assembled according to the project schematic. The system was powered on and initial calibration of the sensors was performed to ensure accurate readings.

Sensor accuracy was tested by gradually changing the soil. The sensor respond accurately to changes in soil moisture levels, providing real-time data to the arduino. The temperature and humidity readings from DHT11 sensor were compared to a standard environmental measurement device to validate the accuracy. Then the MAX7219 display was tested by checking the real-time display of temperature, humidity, and soil moisture status. The display accurately reflected the sensor readings and updated in real-time.

We tested the water pump by setting up the moisture of the soil to dry, so when the YL39 detects the soil levels, the water pump continues to operate until the time set for the water pump is deactivated. There is also a LED indicator to indicate the soil level, if the LED is turned on then the soil is dry.

The entire system was tested for integration issues and stability over an extended period. The sensors, water pump, and display operated smoothly without any hardware or software issues. The system responds to environmental changes, such as humidity, temperature, and soil levels.

e. 3.2 RESULT

The testing results of the plant watering system indicate a highly successful implementation across all critical functionalities of the design. The YL39 soil moisture detects soil moisture levels with high accuracy, the LCD display displays real-time readings of soil moisture and the LED indicator functioned correctly turning on when the soil was dry.

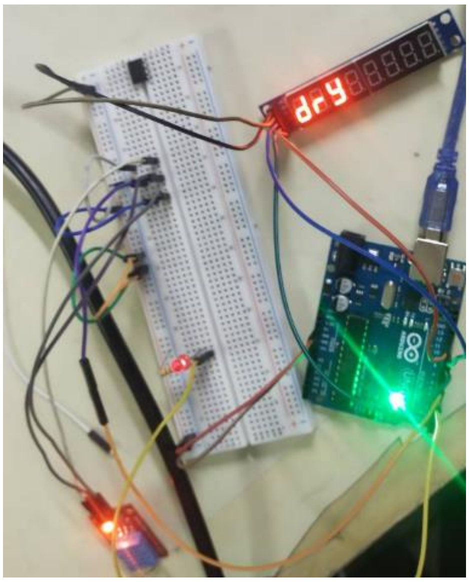


Fig. 3.1 YL39 Testing

The DHT11 sensor effectively measured ambient temperature and humidity. This data was accurately displayed on the MAX7219-driven 8-digit seven-segment display, allowing for real-time monitoring of environmental conditions.

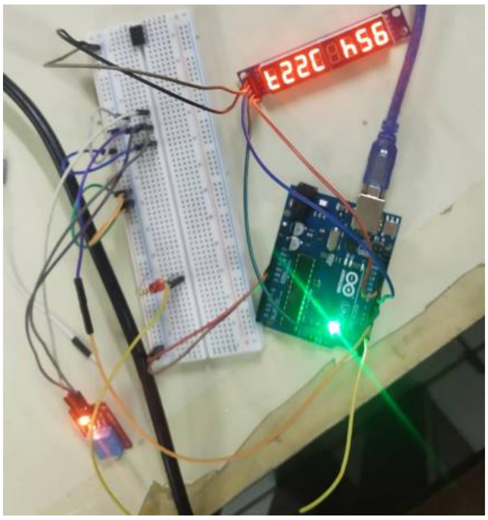


Fig. 3.2 DHT11 Testing

The 5V DC water pump was reliably controlled by the Arduino Uno based on the moisture data from the soil sensor. When the soil was dry, the system successfully activated the pump to deliver water, and deactivated it after a certain time.

Fig. 3.3 Water Pump DC turned on

Overall, the automatic plant watering system met all the acceptance criteria, providing an effective solution for optimizing water usage and maintaining plant health. The system passed all testing phases successfully, exhibiting accurate readings, seamless integration, and efficient performance.

f. 3.3 EVALUATION

The Automatic Plant Watering System, while functional in many respects, has encountered several issues that require attention to enhance its overall efficiency and reliability. This evaluation highlights the primary areas needing improvement, specifically regarding the wiring setup and the procurement of components.

One of the critical issues identified in the current setup is the suboptimal use of wiring, which has directly impacted the performance of the 7-segment display. Poor wiring practices have led to several problems, including unstable connections. Inadequate or loose connections can result in intermittent display functionality, where segments fail to light up consistently, causing incomplete readings. Moreover, poorly organized wiring increases the risk of electrical short circuits, which can damage the display and other components in the system.

During the preparation phase, several components were purchased but ultimately not utilized in the final system. This inefficiency in procurement has led to unnecessary expenditure and clutter, affecting both the budget and the workspace. Issues identified include over-purchasing components without a precise understanding of their necessity for the project and insufficient planning and specification of required components before purchasing, leading to redundant or incompatible parts.

Addressing these key issues will significantly improve the functionality and efficiency of the Automatic Plant Watering System. By refining the wiring practices and optimizing the procurement process, the system can achieve more reliable performance and cost-effectiveness. These improvements will not only enhance the current project but also provide valuable lessons for future developments.

CHAPTER 4

CONCLUSION

Automatic Plant Watering System utilizing Arduino Uno microcontroller represents a significant advancement in the efficient and sustainable management of household plant watering. The goals of reducing water wastage and promoting optimal plant health have been successfully addressed through the integration of smart technology and real-time monitoring.

Key achievements of this project include the effective soil moisture monitoring using YL-39 soil moisture sensor that can accurately detect soil moisture levels and ensuring that plants receive water only when necessary. Environmental condition monitoring used DHT11 sensor to effectively measure ambient temperatures and humidity, providing additional data that can influence watering schedules. Automated Water Delivery using 5V water pump DC through resistor, regulated by the Arduino Uno. This automation ensures that plants are watered consistently and accurately based on real-time moisture data. Using integration of Max7219 drive 8 digit seven segment display provides a clear and real time feedback on soil moisture, temperature, and humidity levels. This allows users to easily monitor the system status and environmental condition. LED indicator as visual alerts when the soil is dry, providing an additional layer of user interaction and ensuring timely intervention if necessary.

By implementing this system, we can achieve significant water savings, reduce the environmental footprint, and maintain healthy plants with minimal effort. The project demonstrates a practical and scalable solution to the inefficiencies of traditional plant watering methods, promoting sustainable living practices and enhancing the efficiency of residential gardening.

Overall, the project combines the power of microcontroller, real-time sensor, and automation to create reliable and effective solutions for plant care. This project not only addresses the immediate need for efficient water use but also sets a precedent for future innovations in smart gardening systems.

REFERENCES

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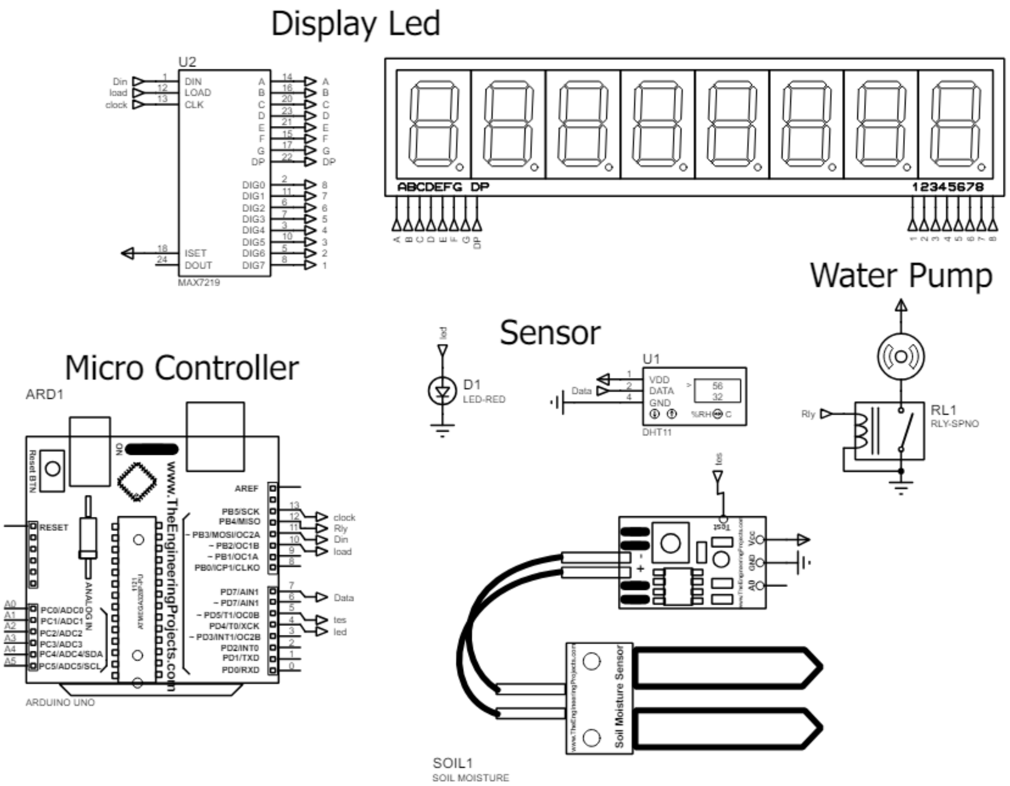
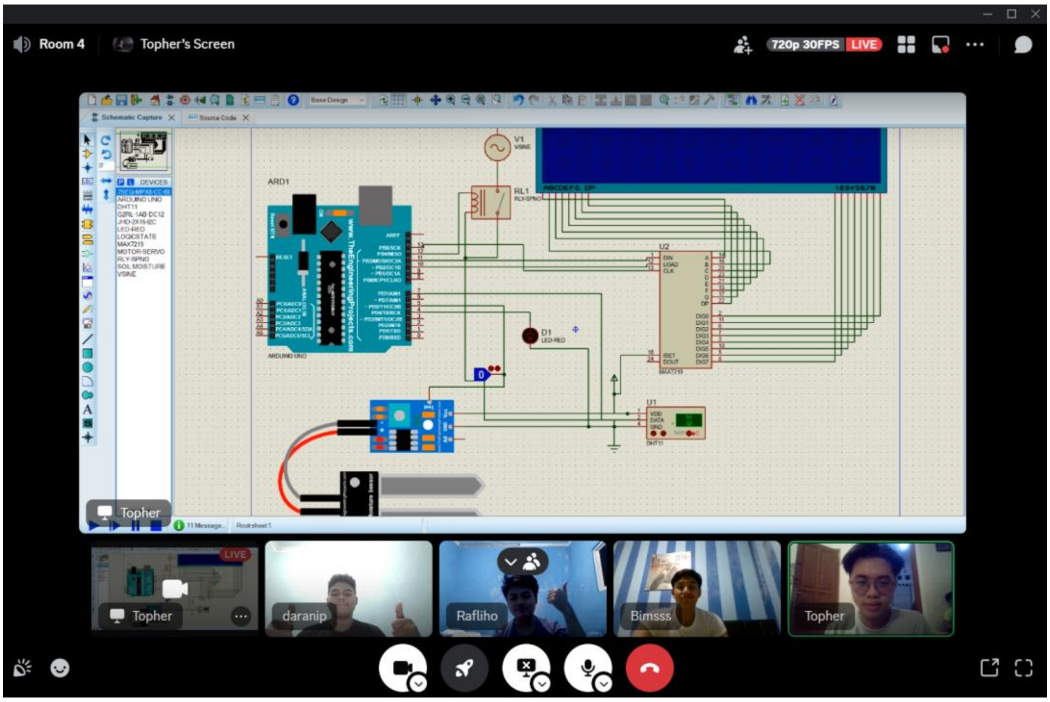
APPENDICES

Appendix A: Project Schematic



Appendix B: Documentation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Topher's Screen
720p 30FPS
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V1
RL1
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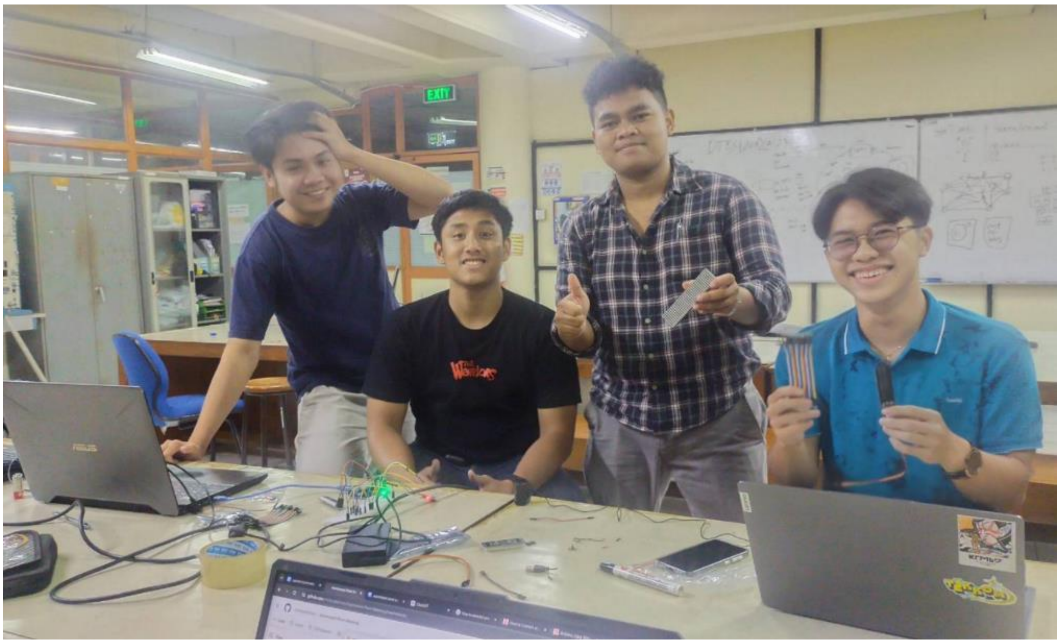
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