Faculty of Electrical Technology and Engineering

DEVELOPMENT OF IOT BASED AUTOMATED PLANT WATERING DEVICE USING PHOTOVOLTAIC SOLAR

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Bachelor of Electrical Engineering Technology with Honours

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DECLARATION

I declare that this project report entitled "Development of an IOT based automated plant watering device using photovoltaic solar power" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	
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Date	:	5/1/2025

DEDICATION

With deepest gratitude and heartfelt appreciation, I dedicate this work to my beloved parents. Your unwavering support, unconditional love, and boundless encouragement have been the foundation of my journey. Your sacrifices, wisdom, and guidance have shaped me into the person I am today. Every step I have taken has been with your faith in me as my guiding light. This achievement is as much yours as it is mine. Thank you for believing in me and for your constant presence in my life.

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ABSTRACT

This research focuses on creating an IoT-based automated plant watering device powered by solar energy. The device uses soil moisture sensors, a NodeMCU ESP8266 microcontroller, and a water pump to provide water based on real-time soil conditions. By using solar energy, the device operates sustainably without needing external power, making it suitable for various agricultural applications. The device is developed to watered the plant automatically, reduce manual effort, and improve resource management. Tests show it can measure soil moisture at optimal levels while using minimal energy. This device improves plant care and supports sustainability by saving water and energy. The study highlights how IoT and renewable energy can help modernize agriculture and make farming more environmentally friendly.

ABSTRAK

Kajian ini memberi tumpuan kepada pembangunan peranti penyiraman tanaman automatik berasaskan IoT yang menggunakan tenaga solar. Peranti ini dilengkapi dengan sensor kelembapan tanah, mikropengawal NodeMCU ESP8266, dan pam air untuk menyiram tanaman berdasarkan keadaan tanah secara masa nyata. Dengan menggunakan tenaga solar, peranti ini beroperasi secara lestari tanpa memerlukan sumber tenaga luaran, menjadikannya sesuai untuk pelbagai aplikasi pertanian. Peranti ini dibangunkan untuk menyiram tanaman secara automatik, mengurangkan usaha manual, dan meningkatkan pengurusan sumber. Ujian menunjukkan bahawa peranti ini dapat mengukur kelembapan tanah pada tahap optimum sambil menggunakan tenaga yang minimum. Peranti ini memperbaiki penjagaan tanaman dan menyokong kelestarian dengan menjimatkan air dan tenaga. Kajian ini menekankan bagaimana gabungan teknologi IoT dan tenaga boleh diperbaharui dapat memodenkan sektor pertanian dan menjadikan amalan pertanian lebih mesra alam.

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LIST OF SYMBOLS

δ	-	Voltage angle
Hz	-	Frequency
A	-	Current
Ah	-	Current hour
V	-	Voltage
T	-	Battery charging time
C	-	Battery bank capacity
R	-	Charging current

LIST OF ABBREVIATIONS

V	-	Voltage
IoT	-	Internet of Things
PV	-	PhotoVoltaic
WiFi	-	Wireless Fidelity
LED	-	Light-emiting diode
OLED	-	Organic Light-emiting diode
DC	-	Direct Current
IDE	-	Integrated development enviroment
AC	-	Alternating Current
GSM	-	Global System for Mobile communication
PIR	-	Passive Infrared Sensor

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CHAPTER 1

INTRODUCTION

1.1 Background

Houseplants have become very popular because they make indoor spaces look nicer, improve air quality, and boost mood and productivity. However, keeping these plants healthy requires regular and proper watering, which can be hard for many plant owners. Busy schedules, forgetfulness, or not knowing how much water that plant needs often lead to either too much or too little watering, harming the plants and possibly killing them.

Watering plants the traditional way, like using a watering can or hose, has its problems. It depends a lot on the person remembering to water the plants and knowing how much water each plant needs, which can vary. Manual watering can take a lot of time and often leads to wasted water. For busy people or frequent travelers, keeping a regular watering schedule is nearly impossible. In places where water is scarce, using water wisely is very important, and traditional watering often uses more water than necessary.

To solve these problems, an automated plant watering device that uses solar power is a great idea. This system uses solar energy to run on its own, making it eco-friendly and cost-effective. It checks soil moisture with sensors and gives the right amount of water, ensuring plants get proper care without human help. This keeps plants healthy and saves water by preventing overwatering. Solar panels ensure the device works even in places without much electricity, making it a versatile solution for plant care.

1.2 Problem Statement

Watering plant using normal way had significant challenges in managing water efficiently, which is essential for plant health and growth. Traditional watering methods often waste water and do not meet the specific needs of different plants. There is a need for new solutions that can deliver the right amount of water based on real-time information. To tackle this issue, we need a system that uses sensors, microcontrollers, and IoT technology to control and monitor watering remotely. This device will ensure plants get the right amount of water when they need it and will be powered by solar energy to be sustainable. By developing such a device, we can make agriculture more efficient and support Sustainable Development Goal 7 (SDG7), which aims to provide affordable, reliable, sustainable, and modern energy for everyone. Using solar power in the automated watering device shows a commitment to using renewable energy, reducing reliance on non-renewable resources, and minimizing the environmental impact of farming.

1.3 Project Objective

The main aim of this project is to propose a systematic and effective methodology to estimate system. Specifically, the objectives are as follows:

a) To design a system that integrates sensors, a microcontroller, and IoT connectivity for remote control and monitoring.

b) To develop an automated plant watering system using IoT technology that delivers water according to sensor data.

c) To evaluate the performance of an automated plant watering device using photovoltaic solar energy

1.4 Scope of Project

The scope of this project are as follows:

a) This project is targeted for using on home outdoor small scales garden.

b) The type of microcontroller used in this project is Node MCU ESP8266.

c) The type of solar panel used in this project is monocrystalline solar panels.

d) The sensors used for checking the moist of the soil is soil moisture sensor.

e) The software application used for the project is Arduino IDE and Blynk website.

f) The type of battery chose for storing power is a Lead Acid battery.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A literature review is a detailed examination of the existing scholarly works related to a particular topic. It aims to summarize and synthesize the current state of knowledge, identify predominant theories and methodologies, and highlight significant findings and research gaps. The objective of a literature review is to study and evaluate what other researchers have done previously and to provide a clear understanding of the research landscape, which informs and guides future studies. By systematically reviewing and integrating past and present research, a research gap of the related project can be identified to further research.

2.2 An Overview of Previous Studies on Automated Plant Watering Devices Using Solar Power

Over the years, many researchers have studied automated plant watering systems to make farming and gardening more efficient and sustainable. Many studies have looked at how effective and reliable these systems are when powered by solar panels. This research has helped develop better technologies and standards for solar-powered irrigation, making these systems more efficient at saving water and keeping plants healthy. Since they use solar energy, they can work without being connected to the main power grid, which is especially useful in remote areas. Overall, these studies have helped reduce water use, lower costs, and support eco-friendly farming practices.

2.2.1 Internet of things: automatic plant watering system using android

This research aims to develop an IoT-based smart watering system that helps plants grow better by automating the watering process. The system uses a soil moisture sensor to check the moisture level in the soil and an automatic controller to water the plants. The device waters the plants in the morning and evening and shows information on an LCD screen and an Android smartphone app. The collected data helps compare and decide if the soil moisture is suitable, affecting how much water is given to the plants.

The system also allows remote control of watering using a WiFi connection shared by the smartphone and the microcontroller. Using IoT in agriculture, especially through automated sprinklers, helps save water and ensures plants get the right amount of moisture based on real-time data. The soil moisture sensor helps decide when to water the plants, preventing overwatering or underwatering, which is crucial for healthy plant growth . The remote-control feature makes the system convenient and efficient, making it a useful tool for modern farming [1] .

2.2.2 Utilization of Internet of Things for Automatic Plant Watering System Using Soil Moisture Sensor

This article talks about using Internet of Things (IoT) technology to create an automatic plant watering device that works with Android and Arduino UNO. The goal is to help farmers and chili plant business owners by automating the daily watering process, which is essential for healthy plant growth but can often be missed due to busy schedules. The system uses a soil moisture sensor to check the moisture level in the soil. If the moisture level goes above 300 RH, the sensor sends a signal to the Arduino, which then turns on the water pump through a relay driver, making sure the plants get the right amount of water. Tests showed that the device works as expected, automatically watering the plants when the soil moisture is above 300 RH and staying off when it's below that level. This automated system not only ensures the plants are properly watered but also saves time and effort for farmers and plant owners, making it a useful tool for modern farming [2].

2.2.3 Implementation and Utilization of Automatic Watering System

This study looks at creating an automated plant watering system to make irrigation smarter and more efficient. The system is designed to control the water flow in the soil with minimal human effort, keeping the soil at the right moisture level for plants. It uses soil moisture sensors to detect the water content in the soil and automatically turns the water pump on or off as needed. This helps prevent water waste and reduces the need for labour and other costs. Efficient water use is very important for farms that rely on irrigation, and there are various methods to schedule watering based on soil moisture, water balance in the soil, and plant stress indicators, often using advanced techniques.

The control system for this automated watering setup is based on sensor technology and an Arduino UNO controller. The sensors measure the soil moisture levels, and the Arduino controls the water pump to ensure the plants get the right amount of water when they need it . This system not only ensures that water is used efficiently and economically but also helps make modern farming more sustainable and effective [3].

2.2.4 Automatic plant watering system using Arduino UNO for university park

Watering plants is one of the most important and time-consuming tasks in maintaining a greenhouse. Automatic watering systems make it easier to ensure plants get the water they need when they need it. Knowing when and how much to water are two key parts of this process. To help gardeners, an automatic plant watering system has been created. These systems can use sprinklers, tubes, nozzles, and other methods. This particular system uses an Arduino UNO board with an ATmega328 microcontroller. It is programmed to detect the soil's moisture level and supply water when needed .

Plants usually need to be watered twice a day, in the morning and evening. The microcontroller is coded to water the plants at these times. Many people find it difficult to keep plants healthy because they forget to water them or are too busy. This automated system is designed to help places like University Park by making sure plants are watered regularly without needing human attention. This prototype aims to make it easier and more enjoyable for people to have plants by taking away the hassle of regular watering [4].

2.2.5 Design of automatic watering system prototype with Arduino-based soil moisture for strawberry plant (Fragaria Ananassa)

This study is designing an automatic water management using an Arduino-based humidity sensor offers practicality in strawberry cultivation, especially in high-temperature areas such as Blitar City. This research aims to design and test a prototype of an automatic watering system for strawberry plants (Fragaria ananassa) using an Arduino-based soil moisture sensor.

The study involved designing the prototype according to specific requirements and testing it to gather soil moisture data and determine the optimal watering times. The research process included four stages: needs analysis, prototype design, testing and evaluation, and final product development. Results showed that the soil moisture sensor, Arduino, and water pump functioned correctly according to the inputs and commands [5].

2.2.6 Experimental and mathematical models for real-time monitoring and auto watering using IOT architecture.

The article discussing on how industries using IoT technology are important for improving farming and watering practices, which are crucial for economic growth. It addresses the big problem of not having enough water, especially in faraway and dry places. To solve this, the paper suggests a system that can monitor and water plants automatically in real-time. This system uses math to figure out how much water the plants need and gives them just the right amount. By doing this, it helps save water and makes farming more efficient.

The system also makes sure that different types of data can work together to help farmers understand their fields better. The heart of this system is a special computer called Arduino, which can sense how wet the soil is and water the plants automatically when needed. This system has shown to be very effective. It saves a lot of water, makes irrigation better, uses less energy, and costs less to maintain. Another important point in the paper is about how important water is for economic development, especially in places where water is scarce. By using IoT technology, industries can help make better irrigation systems, which can improve farming and help economies grow. This paper highlights the importance of systems that can monitor and water plants automatically in real-time, as they can help solve water scarcity problems and support economic growth through smarter farming practices [6].

2.2.7 Automation plants watering system for small garden

This study delves into the rise of automation, particularly with the advent of the Internet of Things (IoT), which connects various devices globally. IoT enables remote monitoring and control of devices through computers or smartphones, offering numerous benefits, including in smart gardening .

The research focuses on creating an automatic plant watering system tailored for small home gardens, called Smart Garden. By using IoT technology, wireless networks, and sensors, the goal is to enhance plant care by enabling real-time monitoring and control of watering processes. Sensors play a crucial role in providing essential soil moisture information, and the Arduino Uno acts as the central controller for managing the entire watering system [7].

2.2.8 IOT-based smart gardening system using Arduino uno

This study explores the development of a Smart gardening system using IoT technology to make home gardening easier by reducing manual work. The system includes various sensors, such as a soil moisture sensor, and humidity and temperature sensors, and uses an ESP8266 microcontroller to alert users when their plants need water. An automatic irrigation system was created using an IoT board, which allows users to monitor and control the system over the internet. The system also features an OLED display and PIR sensors to keep pests away from the plants. Additionally, the project includes a purple LED light to promote plant growth based on research.

Another study highlights the use of IoT technology in enhancing environmental awareness and sustainability through a smart gardening system. This system uses smart sensors to automatically monitor and manage gardening tasks. By integrating IoT, it collects real-time data and allows for remote monitoring, making gardening more efficient and effective. This method simplifies gardening and improves water management and plant health by providing timely information about soil moisture and environmental conditions [8].

2.2.9 Smart irrigation system using IOT

This study highlights the essential role of plants in the ecosystem and the importance of proper cultivation practices. Factors like temperature, water, humidity, and fertilizers significantly affect plant growth. Water, in particular, is crucial; too little can stunt growth, while too much can cause fungal infections and damage plants. The research aims to create an IoT-based system to monitor soil moisture levels and automatically water plants when needed. This IoT tool, which can be controlled via a mobile app, aims to reduce water waste and ensure plants get the right amount of water.

Another study focuses on an IoT-based irrigation system designed to manage water usage efficiently. This system includes sensors that monitor soil moisture, temperature, and humidity, all connected to a NodeMCU microcontroller. The sensors provide real-time data, enabling automatic watering when soil moisture falls below a certain level. This system helps optimize water usage, reduce manual labour, and improve plant health by ensuring consistent and adequate watering [9].

2.2.10 Irrigation system based on Arduino uno microcontroller

Efficient water management is vital for successful crop production, ensuring optimal yields and sustainable agricultural practices. Striking the right balance between providing adequate hydration and avoiding over-watering is crucial to maintaining crop health and productivity. When crops are under-watered, they may suffer from nutrient deficiencies, while over-watering can increase susceptibility to diseases and even lead to root suffocation. Moreover, plants that are consistently over-watered may struggle to survive dry spells during periods of water scarcity, highlighting the importance of precise water management strategies.

In recent years, advancements in irrigation technology have introduced microcontroller-based solutions that revolutionize water management in agriculture. These systems, such as those controlled by an ATmega328 microcontroller, utilize soil moisture sensors to determine when irrigation is needed. By integrating real-time soil moisture data, these systems enable automated and precise irrigation, optimizing water usage and enhancing crop yields. The inclusion of soil moisture sensors allows for adaptive irrigation strategies that respond dynamically to changing environmental conditions, contributing to sustainable farming practices. This review underscores the significance of microcontroller-based irrigation systems and soil moisture sensors in improving water efficiency and crop productivity, thereby supporting the transition towards more sustainable agricultural practices[10].

2.2.11 Automatic Plant Watering System

The Automatic Plant Watering System, as discussed in the research, is a significant advancement in agricultural technology, especially in India. By utilizing Internet of Things (IoT) technology, this system provides a solution to the challenges faced by farmers by helping them monitor and control soil moisture levels effectively. Through real-time updates and automated watering triggered by specific moisture levels, the system ensures plants receive the right amount of water for healthy growth, potentially increasing crop yields.

This technology is crucial in addressing water scarcity and promoting sustainable water management practices. By offering precise soil moisture readings and automated irrigation, the system not only conserves water but also enhances the sustainability of agricultural activities. With further development, it has the potential to revolutionize farming practices, benefiting farmers and contributing to environmental conservation efforts [11].

2.2.12 Automatic Watering System for Plants with IoT Monitoring and Notification

The study introduces a new automatic plant watering system with IoT monitoring and notification, highlighting the importance of soil moisture for plant health and the need for accurate watering to avoid plant dehydration or excessive water. By combining various components like microcontrollers, soil moisture sensors, relays, and solenoid valves, the system can water plants automatically based on soil moisture levels, ensuring plants receive the right amount of water.

Through IoT platforms like Blynk apps and ThingSpeak, users can monitor soil moisture in real-time and receive notifications on their smartphones, making plant care more convenient and effective. Testing showed that the system successfully increased soil moisture levels from 30%-35% to 68.2%, indicating its potential to streamline the plant watering process [12].

2.2.13 IOT Based Smart Plant Monitoring System

IoT-Based Smart Plant Monitoring System" project addresses the essential need for efficient water management in agriculture, especially in areas like India, where a large part of the land relies on monsoon rains for irrigation. By integrating sensors such as humidity, moisture, and temperature sensors into the root zone of plants and using a gateway unit for data transmission, the project aims to optimize soil moisture levels and prevent problems like overwatering that can harm crops and wastewater.

Utilizing technologies like Arduino UNO and NodeMCU 8266, the system ensures precise monitoring and control of water based on real-time sensor data, thus enhancing agricultural productivity and sustainability. The project's focus on automating the irrigation process aligns with the broader goal of reducing human intervention, improving accuracy, and maximizing resource efficiency in farming. By implementing smart plant monitoring solutions, this project contributes to the advancement of IoT applications in agriculture, offering a promising way to revolutionize traditional farming methods and promote sustainable water usage in the agricultural sector [13].

2.2.14 IoT-based smart gardening system using Arduino uno

This research paper delves into the implementation of an innovative smart gardening system that harnesses the power of IoT technology to revolutionize traditional home gardening practices. By integrating a range of sensors such as the soil moisture sensor, humidity and temperature sensor, PIR sensor, and purple LED lights, the system enables precise monitoring and control of essential plant parameters.

Moreover, the incorporation of advanced technologies like machine learning and artificial intelligence enhances the system's capability to analyse data, make informed decisions, and autonomously respond to varying environmental conditions. Through seamless connectivity to IoT cloud platforms and mobile applications, users can remotely oversee and manage their garden, fostering a convenient and sustainable approach to gardening while minimizing manual intervention and promoting environmental consciousness [14].

2.2.15 Internet Of Things Based Plant Watering System Design

The research paper explores plant cultivation technologies, highlighting the importance of intensive care and maintenance practices, such as watering, weeding, and nutrient application, in improving plant productivity. The study presents a new plant watering system that utilises IoT technology to transform conventional plant maintenance methods. The system allows for remote monitoring and precise watering of plants by integrating advanced components such as soil moisture sensors, temperature sensors, NodeMCU ESP 8266, and a DC water pump.

This integration ensures that plants receive optimal growth conditions. This cutting-edge system not only simplifies plant care processes but also provides immediate information on important factors such as temperature, humidity, and connection status through a user-friendly smartphone application. This IoT-based plant watering system establishes a new benchmark for efficient and sustainable plant maintenance practices by integrating technology and agriculture [15].

2.2.16 Arduino based automatic plant watering/irrigation system

The research study focuses on using an Arduino-based autonomous plant watering/irrigation system to address the issue of water shortage in agriculture. It highlights how important automated irrigation is for saving farmers' and gardeners' resources, particularly in areas with insufficient rainfall. The system incorporates humidity sensors for environmental monitoring and uses moisture sensors to detect changes in soil water concentration, which triggers irrigation via a microcontroller.

The article also covers the usage of soil moisture sensors for indirect water content monitoring and the use of resistors in electrical circuits for voltage division and current management. Additionally, it emphasizes how AC motors are integrated into irrigation systems, highlighting their function in transforming alternating current into mechanical energy for effective plant watering [16].

2.2.17 Soil Moisture Monitoring System Applied to the Internet of Things (IoT) Based Automatic Watering Equipment in Papaya Fields

The research project is on developing and deploying an automated plant irrigation system that is connected to a real-time soil moisture monitoring system in papaya fields, utilizing IoT technology. The system employs the FC-28 soil moisture sensor, Arduino UNO microcontroller, a dc pump, 16x2 LCD display, and the Blynk application for monitoring. The study entails gathering data from three papaya farms of different crop ages to evaluate the efficacy of the system.

The system is programmed to irrigate the plants when the soil moisture level drops below 65% or rises beyond 350%, as determined by the sensor data. The FC-28 sensor has exceptional accuracy, boasting an average accuracy rate of 99.21% and a precision rate of 100%. This makes it highly suitable for determining soil moisture levels in papaya fields. The project seeks to tackle the urgent requirement for effective water management in agriculture by offering a dependable and automated method for maintaining ideal soil moisture levels in papaya growing [17].

2.2.18 Automatic Plants Watering System for Small Garden

The integration of Internet of Things (IoT) technology in the agricultural sector has emerged as a revolutionary tool, facilitating remote monitoring, data processing, and cloud-based decision-making for farming enterprises. By incorporating Internet of Things (IoT) technology into agricultural operations, such as intelligent garden systems, families can gain advantages in terms of improved operational efficiency and heightened productivity. These systems utilize cloud computing and smartphone interfaces to provide affordable irrigation systems that are tailored to the unique requirements of tiny gardens.

These automatic plant watering systems use Arduino Uno as a control mechanism and employ soil moisture sensors to precisely monitor the water content in the soil.

The implementation of real-time monitoring enables automatic watering procedures that are customized to the prevailing environmental circumstances, therefore guaranteeing optimal plant development and effective water usage. In summary, the combination of IoT technologies, cloud computing, and smartphone interfaces presents a potential method for plant care, providing accessibility and convenience for home gardeners [18].

2.2.19 Automatic plant Irrigation Control System Using Arduino and GSM Module

The study article explores the creation of a cutting-edge automated plant irrigation control system using Arduino and a GSM module to tackle the urgent challenges related to water management in agriculture. The system aims to improve water consumption efficiency in farming operations by combining important hardware components such as a microcontroller, flow meter, moisture sensor, LCD, and GSM module with sophisticated software elements like C++ code. The suggested technology demonstrates the capacity to substantially decrease water use by 30-50% in comparison to conventional irrigation techniques such as sprinklers.

This promotes sustainable development and controls the spread of weeds by employing precise watering tactics. Furthermore, the relay circuit, consisting of elements such as a transistor, DC generator, and relay, has a crucial function in controlling the water pump according to up-to-date soil moisture information, guaranteeing accurate and efficient irrigation procedures. Additionally, the study emphasizes the crucial necessity of maintaining a consistent 5V power supply for the microcontroller unit in order to prevent any possible harm, emphasizing the utmost importance of precise voltage regulation in complex electronic systems [19].

2.2.20 Designing Plant Monitoring System Using Arduino

The project focuses on developing a plant monitoring system using Arduino. This project is part of the larger field of agricultural innovation, which is increasingly focused on adopting automated solutions to improve plant development and resource management. This project aims to overcome the constraints of conventional plant monitoring systems by utilizing Arduino technology to develop a system that combines sensors for measuring soil moisture and temperature.

By using this approach, the system not only enhances water efficiency and controls the surrounding temperature, but also strives to enhance plant output while minimizing the requirement for continuous human involvement. The use of Arduino as the platform for this system emphasizes a transition towards more effective and dependable data gathering techniques in plant monitoring, showcasing the possibility for enhanced accuracy and precision in agricultural activities.

Moreover, the project's emphasis on preserving uniform soil moisture and temperature levels demonstrates a sophisticated approach to plant maintenance, tailored to the distinct requirements of many plant species and growth phases. The focus on individualized monitoring systems indicates a wider movement towards customized agriculture solutions that may efficiently maximize plant health and productivity [20].

2.3 Comparison of previous work

Table 2.1 shows the comparison of previous work from various methods.

Table 2.1 Comparison of previous work from various method

No.	Title	Functional	Advantages
[1]	Internet of things: automatic plant watering system using android	-Implements morning and evening watering schedules akin to manual farming practices. - Utilizes Wi-Fi network for seamless communication between the smart sprinkler system and the smartphone application.	-Convenient remote monitoring and control via smartphone application.
[2]	Utilization of Internet of Things for Automatic Plant Watering System Using Soil Moisture Sensor	-Utilizes a Soil Moisture Sensor to accurately detect soil moisture levels within specified limits (<= 300 RH and >= 300 RH). -Activates a relay mechanism to control the water pump, ensuring optimal watering by starting and stopping based on soil moisture readings.	-Automates watering based on real-time soil moisture data, ensuring plants receive water only, when necessary, thus optimizing water usage and plant health.
[3]	Implementation and Utilization of Automatic Watering System	-Utilize simulation models based on soil indicators or water balance approaches, potentially incorporating remote sensing techniques, to develop irrigation schedules. - Provide guidance on efficient irrigation application to reduce physical causes and inconvenience.	-Utilization of simulation models allow for precise irrigation scheduling tailored to soil indicators and water balance, enhancing water management efficiency.
[4]	Automatic Plant Watering System using Arduino UNO for University Park	-Utilize multiple sensors for data collection and analysis - Designed to be assistive for University Park and potentially beneficial for humanity in general	- Facilitates precise data collection through the use of multiple sensors, leading to informed decision-making
[5]	Design of Automatic Watering System Prototype with Arduino-Based Soil Moisture Sensor for Strawberry Plants (Fragaria	- Develop an automatic watering system prototype for strawberry plants using Arduino-based technology. - Conducted needs analysis considering air temperature and planting environment.	- Soil moisture sensor provides accurate data, ensuring plants are watered only when necessary, avoiding over or under-watering.

	Ananassa)		
[6]	Experimental and Mathematical Models for Real-Time Monitoring and Auto Watering Using IoT Architecture	-Develop an autonomous sensor-enabled architecture for real-time monitoring of agricultural parameters, emphasizing the significance of sensing and monitoring soil moisture for efficient irrigation management. -Establish the ability of the proposed architecture to minimize water waste and maximize plant growth rates, providing a potential solution for accurate farm management through automatic sensor-enabled technology.	- Enhanced efficiency in irrigation management through real-time monitoring, minimization of water waste, and maximization of plant growth rates using autonomous sensor-enabled architecture.
[7]	Automatic Plants Watering System for Small Garden	- Offering a model of a watering system tailored for small-scale use, potentially applicable to urban gardening or home-based cultivation. - Implementing IoT technology to enhance plant care and contribute to addressing climate change.	-Enhancing plant care efficiency and promoting sustainability through the integration of technology, automation, and IoT in small-scale gardening practices.
[8]	IoT-based smart gardening system using Arduino uno	- his system employs IoT to precisely monitor soil moisture, ensuring crops receive the right amount of water. It saves resources and money by reducing water wastage. - By automating tasks and simplifying gardening, this system promotes home gardening. It not only makes gardening easier but also contributes to sustainability for future generations.	- The project optimizes water usage through precise monitoring, thereby conserving resources and reducing costs while promoting sustainable gardening practices.
[9]	Smart Irrigation System Using IoT	- The project uses sensors to keep track of soil moisture, temperature, and humidity. When the soil gets too dry, it turns on a water pump automatically to hydrate the plants. This eliminates the need	- Utilizing NodeMCU enhances scalability and connectivity through its Wi-Fi capability. This allows for remote monitoring and control, enabling the system to be easily scaled up to

		for manual checking and watering. - By using NodeMCU, the system can store data efficiently, consume less power, and connect to Wi-Fi. This means you can monitor and control irrigation remotely. Compared to Arduino, NodeMCU offers better capabilities for expanding the system to cover large farms and fields effectively.	manage larger areas such as farms and grounds. Additionally, the system's compatibility with NodeMCU enables seamless integration with other smart agriculture technologies for comprehensive farm management.
[10]	Irrigation system based on Arduino uno microcontroller	- The system functions to continuously monitor the moisture levels in the soil using an SMS YL-69 sensor, providing real-time feedback on soil conditions. - Based on the soil moisture readings, the system autonomously controls the watering system/pump, toggling it on or off as per predefined moisture thresholds, ensuring efficient water usage and optimal plant growth.	- This project helps save water by only watering plants, when necessary, based on the soil moisture levels, which promotes healthy plant growth while conserving water resources.
[11]	Automatic Plant Watering System	-The Automatic Plant Watering System operates by sensing the soil moisture content of plants and activating a motor to supply water when the moisture falls below a set threshold. -It utilizes IoT technology to connect to the internet, allowing users to receive updates on moisture levels and automate the watering process based on real-time data	-Promotes water conservation by delivering water only when necessary, contributing to sustainable water management practices

[12]	Automatic Watering System for Plants with IoT Monitoring and Notification	-The system detects soil moisture levels using sensors and activates the watering function when levels are between 30% - 35%, ensuring plants receive adequate hydration. -Integration with IoT platforms like Blynk apps and ThingSpeak allows for real-time monitoring of soil moisture levels and provides notifications to users	- Automating the watering process based on soil moisture levels prevents under or overwatering, promoting healthier plant growth and reducing the risk of plant damage
[13]	IoT Based Smart Plant Monitoring System	-The project creates a smart system to watch over plants using sensors to check soil conditions and water the plants automatically. -It uses a small computer called Arduino UNO to control the system.	-make sure plants get the right amount of water, preventing them from getting too much or too little water
[14]	IoT-based smart gardening system using Arduino uno	- Monitoring water levels in plants using a soil moisture sensor, temperature, and humidity sensors - Control of sensors using the ESP8266 microcontroller chip	- Enables precise monitoring and control of essential plant parameters for optimal growth and health.

[15]	Internet Of Things Based Plant Watering System Design	- Shows plant info and allows watering control. - The system waters plants automatically based on their needs.	- Allows remote monitoring and watering, reducing manual intervention.
[16]	Arduino based automatic plant watering/irrigation system	- Moisture sensors detect changes in water concentration in the soil, triggering irrigation through a microcontroller. - Humidity sensors monitor environmental conditions to ensure optimal plant growth and resource management.	- It saves time, money, and power for farmers and gardeners by automating the irrigation process.
[17]	Soil Moisture Monitoring System Applied to the Internet of Things (IoT) Based Automatic Watering Equipment in Papaya Fields	- Used a soil moisture sensor, microcontroller, pump, LCD display, and monitoring app. - Developed a system to water papaya plants automatically based on soil moisture levels.	- Provides a closed-loop system that efficiently manages water resources by watering plants only when necessary, promoting water conservation in agriculture.

[18]	Automatic Plants Watering System for Small Garden	- Users can monitor and control the plant watering system from a computer or smartphone. - Sensors measure soil moisture levels to determine when plants need watering.	- Ensures plants get the right amount of water. Monitor and control from anywhere.
[19]	Automatic plant Irrigation Control System Using Arduino and GSM Module	- The project creates a smart system to automatically water plants using Arduino and a GSM module. - The system saves water (30-50%) compared to traditional methods, promoting better plant growth and reducing weed growth.	- Efficient water usage due to automated irrigation control. Improved plant growth and reduced weed growth.
[20]	Designing Plant Monitoring System Using Arduino	-The system utilizes a moisture sensor to efficiently manage soil moisture levels, ensuring optimal hydration for plants while minimizing water wastage. -By incorporating a temperature sensor and fan, the system aims to control ambient temperature. Enhancements in cooling capabilities, such as a larger fan, are recommended to improve temperature regulation in open spaces, thereby creating an ideal growth environment for plants.	-The system enables customized environmental conditions tailored to each plant's specific needs, promoting precision agriculture and enhancing plant productivity

2.4 Summary

These projects showcase how IoT technology is revolutionizing plant watering systems, offering smart solutions for efficient water usage and optimal plant health. By integrating sensors and automation, these systems can monitor soil moisture levels in real-time and deliver water precisely when needed, eliminating guesswork and conserving water resources.

Whether it's through morning and evening watering schedules, simulation models for irrigation, or prototypes tailored for specific plants like strawberries, each project contributes to sustainable gardening practices. With features like remote monitoring via smartphones and scalability for larger agricultural areas, these innovations pave the way for smarter, more environmentally friendly farming methods.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the methodology of the development of an automated plant watering device powered by solar energy. It discusses how the system is designed to maintain healthy plants by managing water and soil moisture levels. The microcontroller NodeMCU ESP 8266 is utilized to control the system efficiently. By integrating solar power with smart soil moisture sensing and automated watering mechanisms, the aim is to simplify plant care while promoting environmental sustainability. The process of building the system is detailed to highlight its effectiveness in maintaining plant well-being without wasting water or energy.

3.2 Methodology

This project will entail various hurdles, such as the requirement for specific procedures or methodologies and the analysis of information. The term "methodology" can be defined as a systematic approach that is employed to investigate deductive reasoning or as a technique for accomplishing a task. This device prototype utilizes photovoltaic solar energy to analyze the effectiveness of a plant watering system by detecting soil moisture and delivering water to the soil. Figure 3.1 shows the project flowchart.

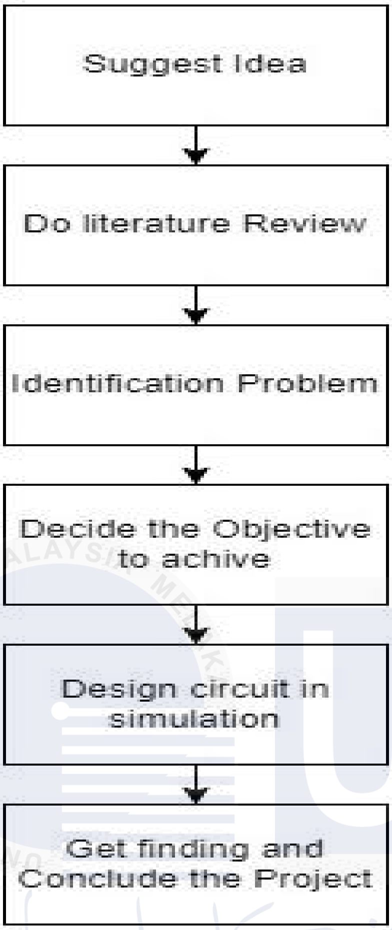


Figure 3.1 Project flowchart

3.2.1 Project architecture

An essential visual representation of a whole project or programming is a flow chart.

The procedures are explained in a sense-based order. The project's whole trajectory, from concept to conclusion, is shown in the flow chart. The sequential development of a project from the start to the conclusion is displayed in the flowchart. Pre-development includes research, data collection, and a thorough grasp of functional design and programming languages. The first stage of development is incorporating the data collection method into the Arduino code after pre-development. The simulation results are converted into hardware and applications for the last iteration during the post-development stage. Figure 3.2 shows the flow chart of the device.

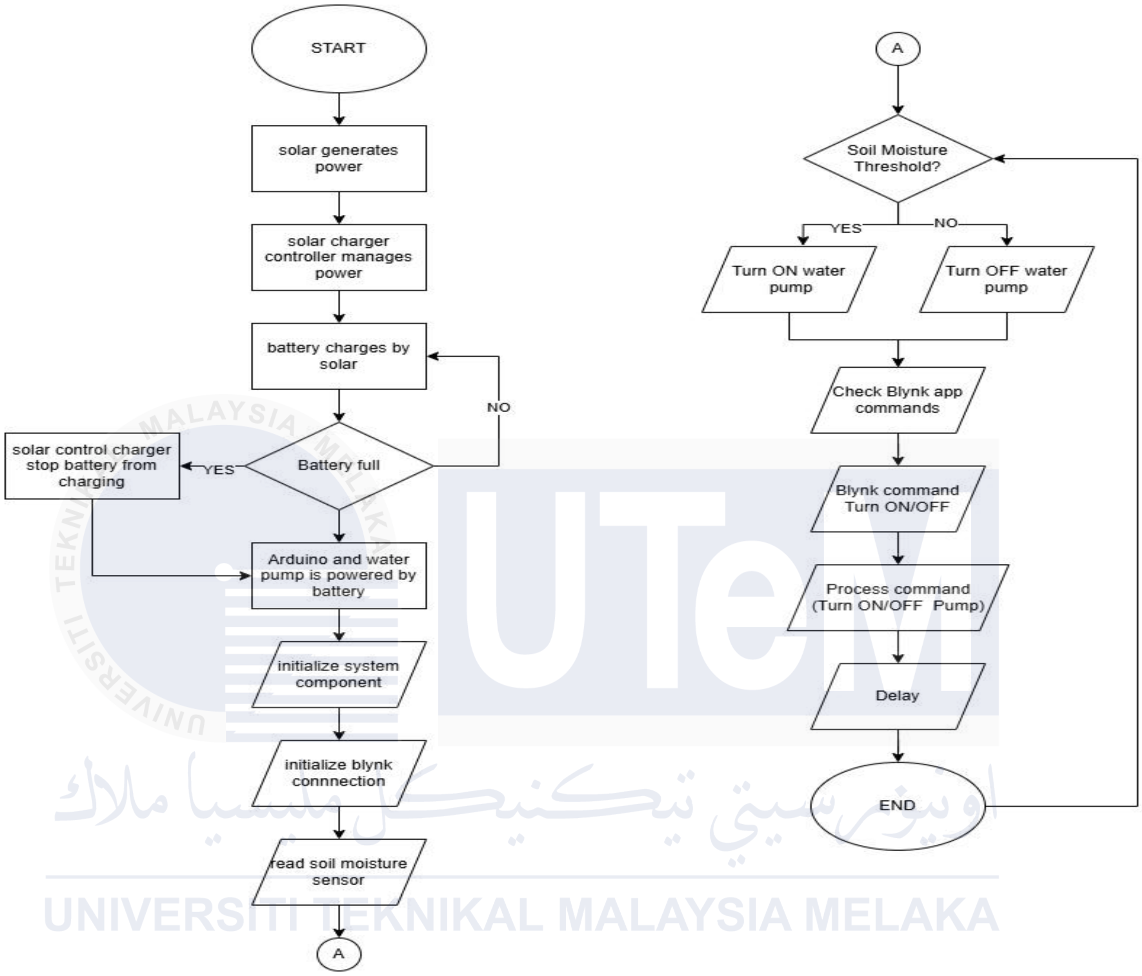


Figure 3.2 Device flowchart

3.2.2 Project Block Diagram

A project block diagram is an illustration that shows the essential elements and their interconnections inside a project, offering a broad summary of the system's structure. A common representation consists of blocks that indicate significant components or functional components, connected by lines or arrows that signify the movement of data, control signals, or resources between them. This diagram facilitates comprehension of the project's structure and workflow, enhancing communication among participants and interested parties by providing a detailed and easily understood representation of the integration and operation of various project components. This representation simplifies difficulties, facilitating the identification of dependencies, potential bottlenecks, and possibilities for optimisation. Figure 3.3 shows the block diagram of the project.

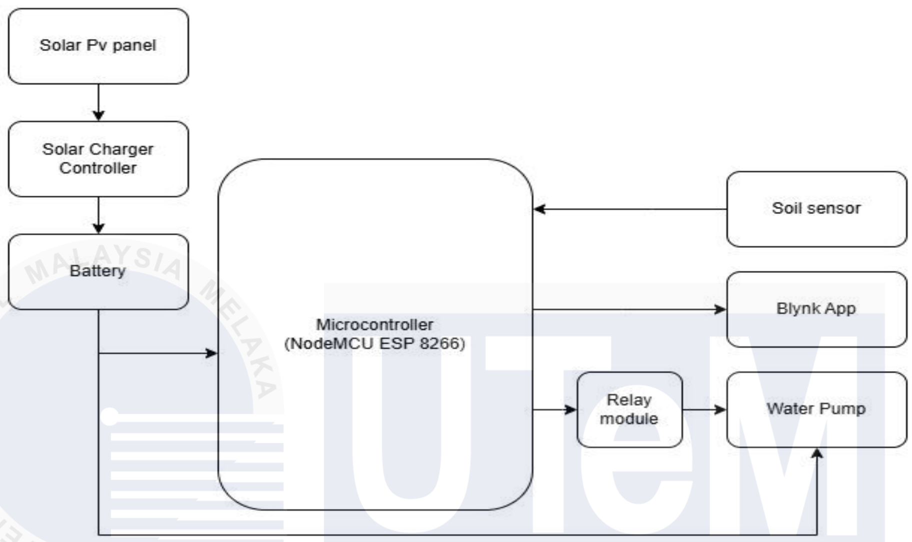


Figure 3.3 Block diagram of the project

a) Solar PV panel is the source of supply that is needed for the project.

b) Solar charge will capture the supply from the PV panel and will charge the battery and can prevent the battery from overcharging.

c) Battery is used to supply the voltage to Arduino and water pump.

d) Microcontroller NodeMCE ESP 8266 is the brain of the device that are given instruction to run the project.

e) A soil sensor is the input component that will detect the soil moisture.

f) To get the information for the project, Blynk Application is used for the project.

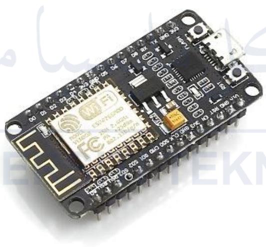
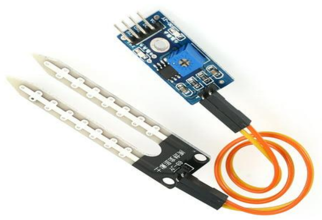
g) Relay will act as a switch for the microcontroller to control the water pump.

h) Water pump will activate when the sensor detected the dehydration of the soil.

3.3 Hardware Components

Any project needs hardware, but notably an early prototype, since it is necessary to replicate actual real data and duties precisely. The result of a simulator is determined by computer/software calculations and ignores environmental considerations. As such, projects that just use simulation software will not be able to gather real data or function. The excellent equipment improves our skills in design and modelling and helps them to learn more about the hardware components. Table 3.1 show the components used for the project.

Table 3.1 Hardware components

Component	Description
NodeMCU ESP8266 	-The ESP8266 module allows the connection of microcontrollers to 2.4 GHz Wi-Fi networks, utilizing the IEEE 802.11 bgn standard. It can be utilized in conjunction with ESP-AT firmware to offer Wi-Fi connectivity to external host MCUs.
Soil Moisture Sensor 	- The soil moisture sensor is a component linked to an irrigation system controller that measures the amount of moisture in the soil within the area where the roots are actively growing.
Relay Module (5vdc) 	- An Arduino setup requires a 5 DC relay in order to use the low-power signals from the Arduino to control high-power devices, like water pumps. By functioning as an electronic switch, the relay enables a smaller control signal to regulate a greater electrical load.

Water Pump (5vdc) 	- A 5 Volt water pump is a motor that operates on a 5V direct current power supply and is specifically designed to pump water. The device utilizes centrifugal force, generated by a rapidly rotating impeller, to enhance, transfer, elevate, or circulate liquids such as water, oil, or coolant.
10Watt Solar PV module (Monocrystalline) 	- A 10-watt solar PV panel is a compact and effective apparatus that transforms sunlight into electrical energy. The device is approximately the same size as a typical laptop and is designed to endure outdoor conditions. This device is ideal for recharging batteries, supplying power to small electronic devices, or generating electricity in isolated locations.
Solar Charger Controller 	- A solar charge controller regulates the flow of power from the solar array to the battery bank. It keeps the deep cycle batteries from being overcharged during the day and prevents the batteries from being drained overnight by running the power backwards to the solar panels.
Battery (12v Lead Acid) 	- A 12V lead-acid battery with 7.0 Ah capacity is a rechargeable battery commonly used in vehicles and backup systems. It uses lead plates and a liquid electrolyte to store energy, offering reliable performance and high current delivery.

3.4 Software Development

Software development is the systematic procedure of designing and constructing computer programs or applications with the purpose of accomplishing specific tasks or functions. Software development covers the activities of designing, coding, testing, and maintaining software in order to fulfill the requirements of the project. Table 3.2 shows the software used to run the project.

Table 2.2 Software development

Software	Description
Arduino IDE	- The Arduino Integrated Development Environment (IDE) includes a code editor, a message area, a text console, a toolbar containing frequently used function buttons, and a collection of menus. It establishes a connection with the Arduino hardware to upload programs and facilitate communication with them.
Blynk Software	- Blynk enhances IoT projects by offering an intuitive application interface for device control and data monitoring. This device has the ability to be utilized with microcontrollers like Arduino, offering real-time tracking, notifications, and collaboration functionalities.

3.4.1 Blynk

Blynk.Console is an advanced IoT platform that enables real-time monitoring and control of devices. It provides an intuitive interface for the creation of dashboards, allowing users to visualize sensor data and remotely interact with hardware components. Developers can customize the layout to align with specific project requirements through the use of basic drag-and-drop tools, integrating widgets for data visualization, control, and notifications. Blynk facilitates the seamless integration of IoT systems by offering reliable connectivity via Wi-Fi or cellular networks. Figure 3.4 illustrates the Blynk Web Console, which displays the programming interface required for the IoT component, while Figure 3.5 represents the complete Blynk application for the project design.

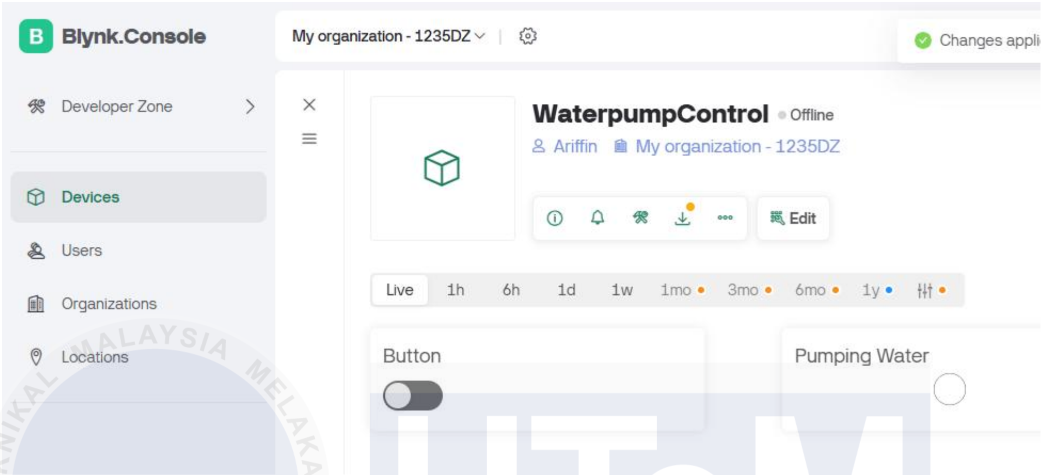


Figure 3.4 Blynk web console

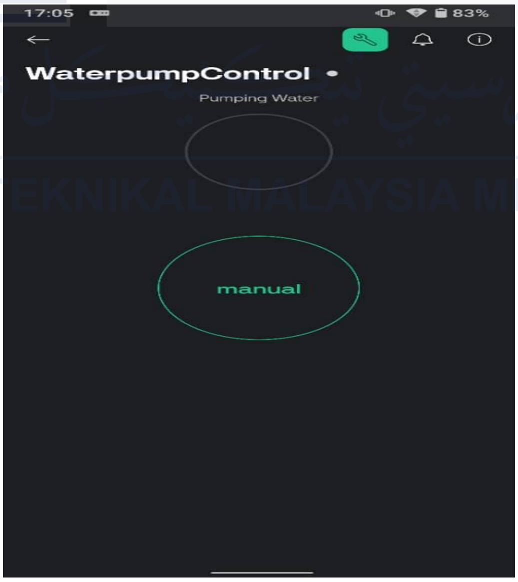


Figure 3.5 Blynk application

3.5 Project Design and installation

Preliminary consideration was directed towards the selection of materials to be employed and the determination of project dimensions, originating from a fundamental design concept. To ensure structural stability, approximate measurements are determined by taking into account the height and dimensions of the project design. Figure 3.6 shows the cutting process for the base of the device. Figure 3.7 shows the assembly process of the device.

Figure 3.6 Cutting process

Figure 3.7 Assembly process

Figure 3.8 shows the wiring process of the device. Figure 3.9 shows the device prototype that has been completely assembled.

Figure 3.8 Wiring process

Figure 3.9 Device prototype

3.6 Experiment setup for Case 1, Case 2, Case 3

The initial phase of the experiment, Design Case 1, aims to assess the capacity of solar energy to generate power. This power is supported by a solar charge controller, which charges the battery and regulates the load on the project system, which includes a relay-controlled motor (DC water pump). Case 2, the subsequent experiment, aims to evaluate the power consumption of the load prototype, as well as to manually operate the water pump per pump the Blynk app. Case 3, the final experiment, involves utilizing the Arduino IDE serial monitor as a data logger to collect data on soil moisture trends and energy consumption of water pump. Table 3.3 shows the Source Type and Mode of each case.

Table 3.3 Source type and mode

Casees	Source Type	Mode
1	Solar and battery	3 days operation
2	Energy consumption	Device running with/without water pump on
3	Soil moisture Threshold	Serial monitor from Arduino ide to get data of the soil sensor threshold

3.7 Summary

The methodology describes the suggested process for development of an IOT based automated plant watering device using photovoltaic solar. The main goal of this methodology is to develop a simple, yet thorough, approach for watering plants. Moreover, the methodology strives to employ easily obtainable data and resources, thereby enabling convenient implementation and operation of the automated system. This approach emphasizes the attainment of simplicity and efficacy in watering needs and solar energy accessibility. The objective is not to pursue absolute accuracy, but rather to prioritize efficiency, user-friendliness, and practicality in implementing the automated watering device.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter discusses the results of developing an automated plant watering device powered by solar energy. The project aims to create an efficient system that uses solar power to water plants, reducing the need for manual intervention and optimizing water use. The focus is on designing a simple yet effective device that uses readily available data and resources. The results show that the device can estimate watering needs accurately while being easy to use and efficient. By utilizing solar power, the system can operate continuously, even in remote areas, promoting sustainability. These findings suggest that this approach is significantly improve plant care and resource management..

4.2 Data Collection

The data collection for this study was employed to evaluate the effectiveness and reliability of the Development of IoT-based automated plant watering device using photovoltaic solar. Figure 4.1 shows the real-time voltage and current measurements generated by the photovoltaic solar panel and stored in a 12V battery were obtained using digital multimeters and power meters throughout the experiment for Case 1.

Figure 4.2 shows the prototype reliability testing for Case 2 was conducted to assess the system's performance. The system was operated continuously over a period of hours for 3 days, with failures or malfunctions being documented. Figure 4.3 shows for Case 3, the Blynk app was utilized to manually control the water pump, providing the flexibility to interact with the system remotely. Data collection was conducted using Arduino's serial monitor data loggers to gather information on soil moisture. Additionally, basic statistical analyses were performed to evaluate trends and calculate averages in system performance, enhancing the overall effectiveness of the automated plant watering system.

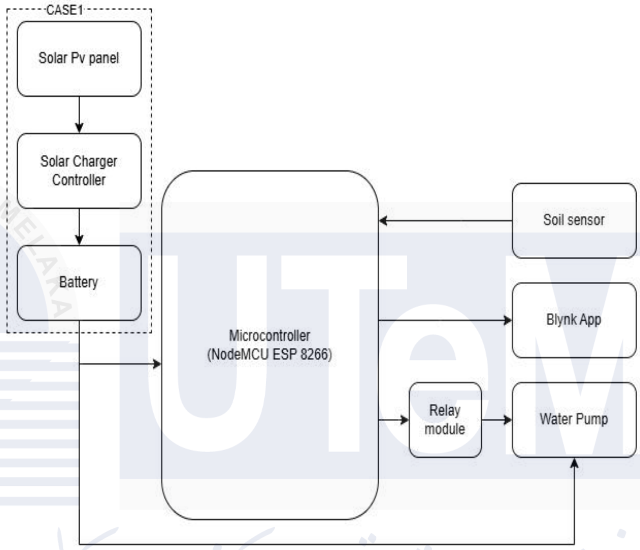


Figure 4.1 Case1

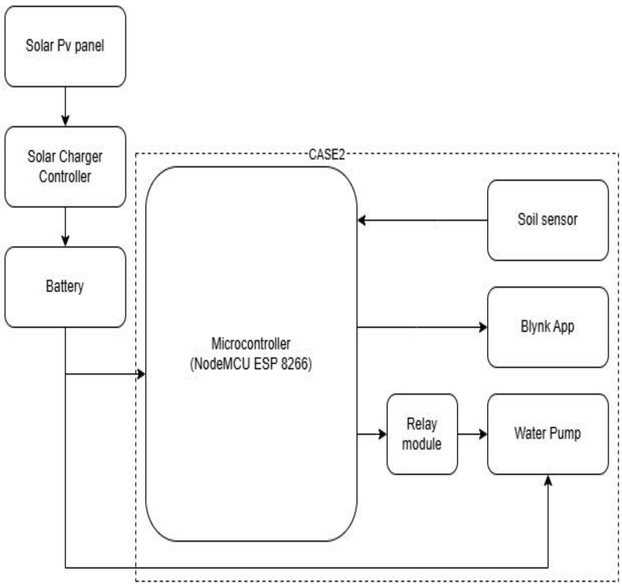


Figure 4.2 Case 2

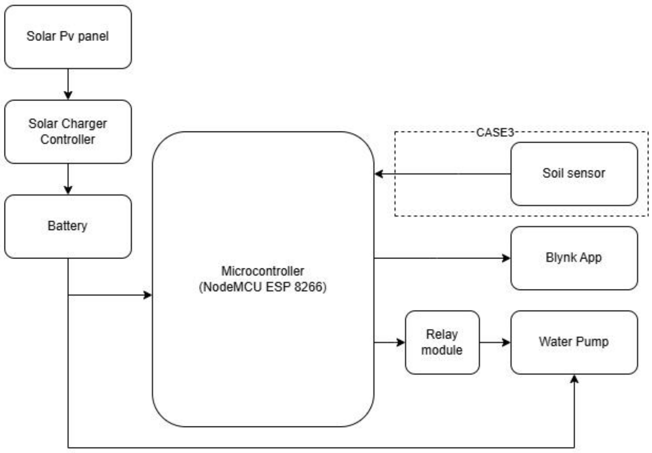


Figure 4.3 Case 3

4.2.1 Case 1

Case 1 examines the implementation of solar energy and battery storage for powering the device. The system was operated over a three-day period to evaluate its performance, with the solar panel charging the battery during daylight hours and the device relying on stored energy during nighttime. Measurements were taken for voltage and current generated by the photovoltaic solar panel, as well as for the charging and discharging cycles of the battery. This evaluation provides a comprehensive understanding of the solar energy system's efficiency, the storage capacity of the battery, and the system's overall functionality in real-world conditions. The objective is to validate the system's ability to sustain consistent performance, particularly in meeting energy demands when solar energy is unavailable.

4.2.1.1 Solar data for Case 1

The data collected during the Case 1 experiment, conducted from 8:00 AM to 7:00 PM on November 21, 2024, till November 23, 2024, was successfully utilized for input analysis.

Table 4.1 Solar data for Case 1

Date: 21 / 11 / 2024				
Time	Solar voltage, V	Solar current, A	Power , W	remark
8.00a.m	12.8	0.16	2.05	Sunny
9.00a.m	12.8	0.16	2.05	Sunny
10a.m	12.9	0.36	4.64	Sunny
11a.m	13.3	0.51	6.78	Sunny
12.00p.m	13.3	0.50	6.65	Sunny
1p.m	13.3	0.52	6.92	Sunny
2p.m	13.2	0.42	5.44	Sunny
3p.m	12.7	0.17	2.16	Shady
4p.m	12.8	0.14	1.79	Shady
5p.m	12.8	0.03	0.38	Shady
6p.m	12.7	0.01	0.13	Sunny
7p.m	12.5	0.01	0.13	shady
Date: 22 / 11 / 2024				
Time	Solar voltage, V	Solar current, A	Power , W	remark
8.00a.m	12.8	0.15	1.92	Sunny
9.00a.m	12.8	0.15	1.92	Sunny
10a.m	13.2	0.30	3.96	Sunny

11a.m	13.2	0.35	4.62	Sunny
12.00p.m	13.6	0.52	7.07	Sunny
1p.m	13.6	0.51	6.94	Shady
2p.m	13.3	0.42	5.59	Sunny
3p.m	13.3	0.34	4.52	Sunny
4p.m	12.8	0.28	3.58	Sunny
5p.m	12.7	0.21	2.67	Sunny
6p.m	12.6	0.02	0.25	Shady
7p.m	12.5	0.01	0.13	Shady
Date: 23 / 11 / 2024				
Time	Solar voltage, V	Solar current, A	Power , W	remark
8.00a.m	12.8	0.16	2.05	Sunny
9.00a.m	12.9	0.22	2.84	Sunny
10a.m	13.0	0.36	4.68	Sunny
11a.m	13.8	0.55	7.59	Sunny
12.00p.m	13.8	0.55	7.59	Sunny
1p.m	13.5	0.44	5.94	Sunny
2p.m	13.5	0.44	5.94	Sunny
3p.m	13.3	0.39	5.19	Sunny
4p.m	12.5	0.14	1.75	Shady
5p.m	12.5	0.03	0.38	Shady
6p.m	12.4	0.01	0.12	Shady
7p.m	12.4	0.01	0.12	Shady

Figure 4.4, Figure 4.5 and Figure 4.6 shows the graphs depict the variations in voltage (V), current (A), and power output generated by a solar panel over three consecutive days: November 21, 2024, November 22, 2024, and November 23, 2024. Representing each electrical parameter with distinct lines, the graphs highlight their changes throughout each day. The data reveals valuable insights into the solar panel's behaviour, showcasing key trends such as peak performance times, consistency in power generation, and potential anomalies. These visualizations provide a comprehensive understanding of the solar panel's electrical characteristics and their evolution over the analysed period.

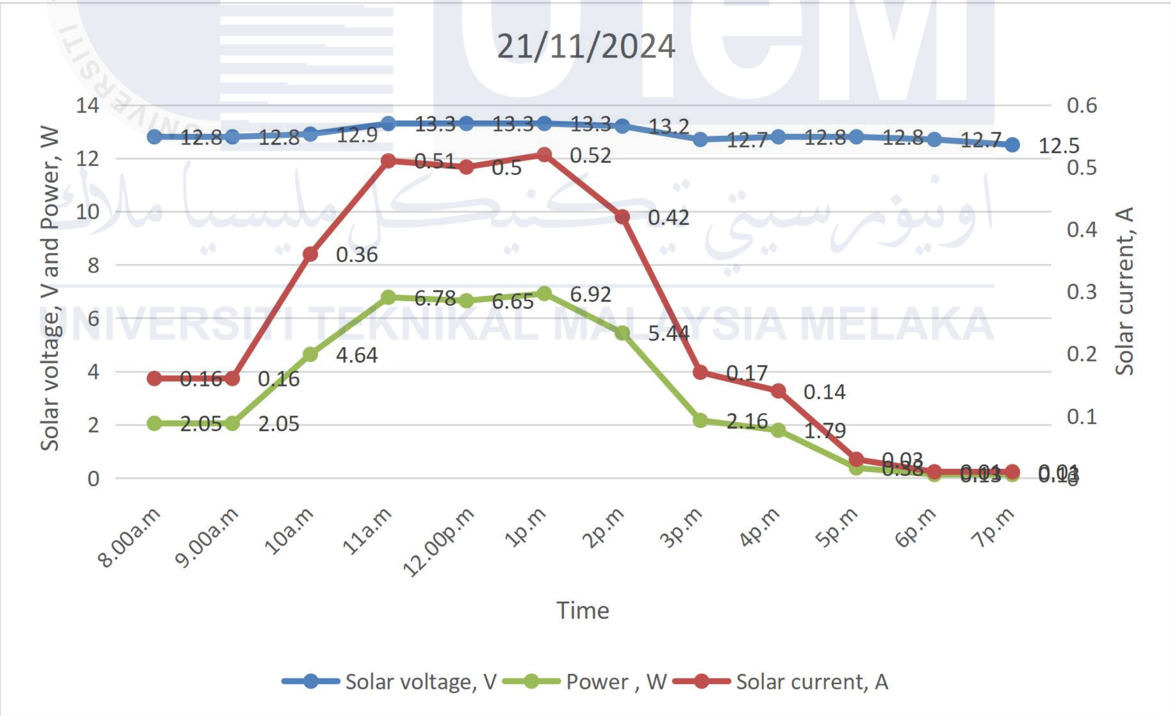


Figure 4.4 Voltage (V), Power, W vs Current (A) vs Time graph generated by solar panel on date 21/11/2024

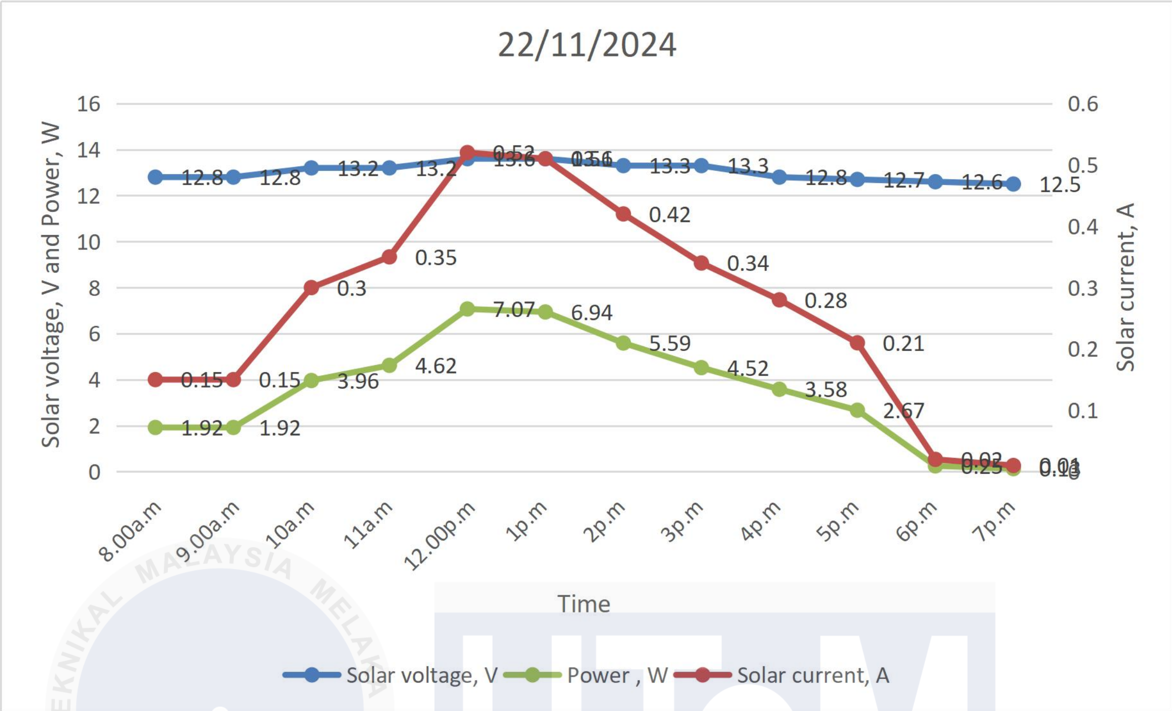


Figure 4.5 Voltage (V), Power, W vs Current (A) vs Time graph generated by solar panel on date 22/11/2024

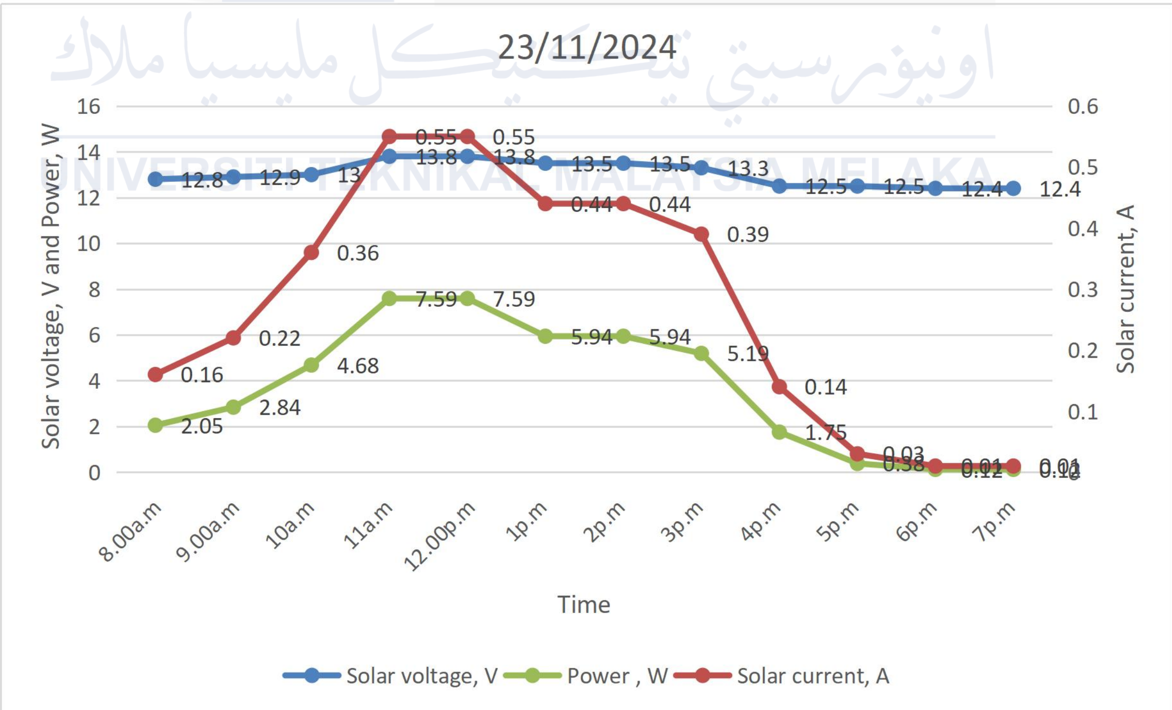


Figure 4.6 Voltage (V), Power, W vs Current (A) vs Time graph generated by solar panel on date 23/11/2024

4.2.1.2 Average battery charging hour to full

The average peak solar hours, typically occurring between 10 a.m. and 2 p.m., represent the optimal time frame for harnessing solar energy to charge batteries efficiently. During this period, solar irradiance is at its highest, enabling maximum energy generation from solar panels. The charging time of a battery bank can be calculated using the formula $t=C/R$ where t represents the charging time in hours, C is the battery bank capacity (7.0 Ah), and R is the solar current in amperes (A).

This formula provides a direct relationship between the battery's capacity and the available charging current, allowing for an estimation of the time required to charge the battery to full capacity during peak sunlight hours. Utilizing this period not only ensures effective charging but also optimizes the use of available solar energy. Table 4.2 shows the Average peak hour solar from 10a.m to 2p.m to charge battery until full.

Table 4.2 Average peak hour solar from 10a.m to 2p.m to charge battery until full

Average				
Day	Solar voltage, V	Solar current, A	Power , W	Battery hour to full, hour
1	13.2	0.46	6.07	15.2
2	13.4	0.42	5.63	16.6
3	12.9	0.36	4.64	19.4

4.2.2 Case 2

In Case 2, the analysis focuses on the energy consumption and battery life of a device equipped with a 7Ah battery, operating under varying conditions. The device has a baseline current draw of 0.03A, which increases to 0.15A when a water pump is activated. The pump, triggered by a soil sensor detecting dry soil, operates twice daily for 6 seconds per activation. Figure 4.7 show the current reading when device on without water pump active, while Figure 4.8 shows the current reading when device on with the water pump active.

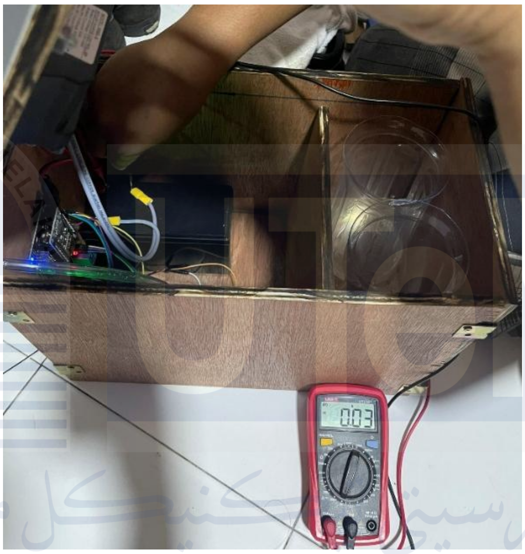


Figure 4.7 The current reading when device on without water pump active

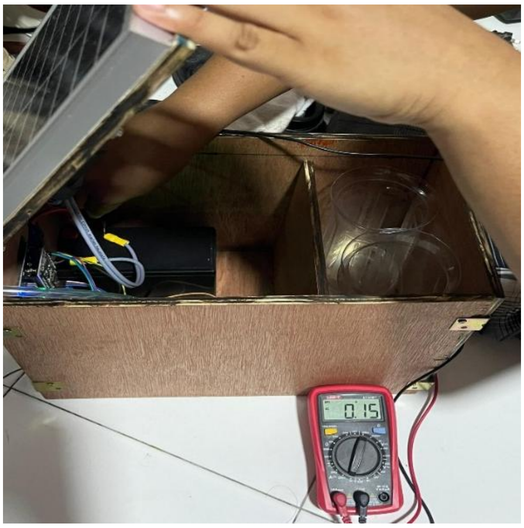


Figure 4.8 the current reading when device on with the water pump active

4.2.2.1 Energy Consumption under two conditions

The battery life of the device is analysed under two conditions: when the water pump is not activated and when it is. In the first condition, where the device operates continuously without the water pump, the current draw is 0.03A. The battery life is calculated using the formula: Battery Life (hours)= Battery Capacity (Ah) / Current (A) = 7/0.03 ≈ 233.33hours. This gives a battery life of approximately 9.72 days. In the second condition, where the water pump is activated twice a day for 6 seconds each time, the current increases to 0.15A during pump operation, which is 0.12A higher than the baseline 0.03A.

The additional energy consumed by the pump per activation is calculated as: Energy per activation (Ah) = 0.12 × (6/3600) = 0.0002 Ah. Since the pump is activated twice a day, the total energy consumed by the pump daily is: Daily Energy (Ah) = 2×0.0002 = 0.0004Ah. Next, the daily energy consumption of the device without the pump is calculated by: Device Energy (Ah) = 0.0 3× 24 = 0.72Ah. Adding the pump's energy consumption, the total daily energy consumption: Total Daily Energy (Ah) = 0.72 + 0.0004 = 0.7204Ah. the battery life with the pump activated is calculated using Battery Life (days) =

Battery Capacity (Ah) / Total Daily Energy Consumption (Ah) = 0.72047 ≈ 9.72days. Thus, the battery life with the water pump activated is approximately 9.72 days, no reduction from the 9.72 days without the pump. This demonstrates that the water pump's infrequent and short activations have a minimal impact on the overall battery life of the device. Table 4.3 shows battery life analysis of the device in two operating conditions (without and with water pump). Figure 4.9 shows Battery Life Comparison of the Device: Without and With Water Pump Activated

Table 4.3 battery life analysis of the device in two operating conditions (without and with water pump)

Condition	Current Draw, A	Energy Consumed per Day, Ah	Battery life, Days
Device operation without water pump	0.03	0.72	9.72
Device operation with water pump	0.15 (during pump)	0.7204	9.72

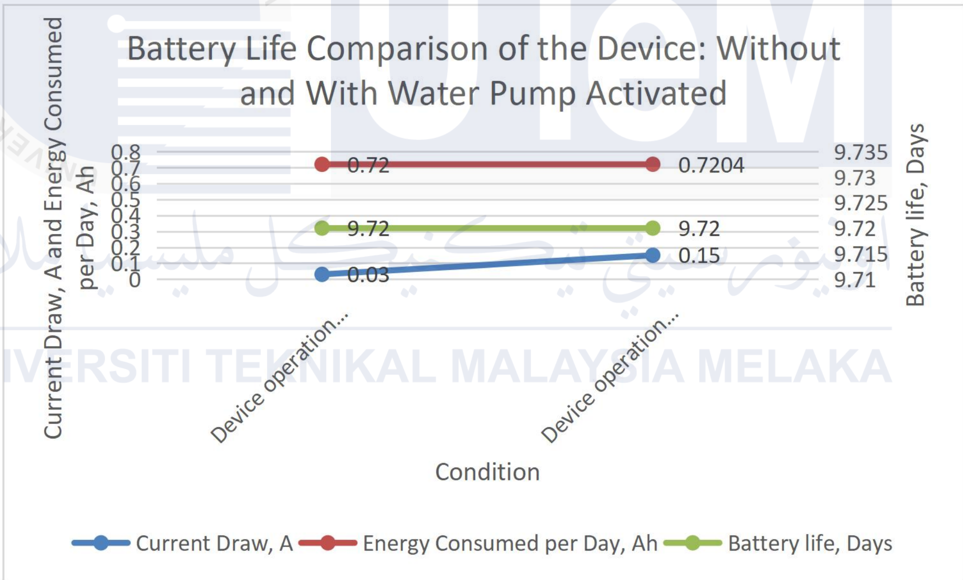


Figure 4.9 Battery Life Comparison of the Device: Without and With Water Pump Activated

4.2.3 Case 3

In Case 3 experiment involving the soil moisture sensor system, the setup evaluates the sensor's performance in monitoring and controlling irrigation under three distinct moisture conditions: wet and dry soil. The sensor operates within an analog range of 0 to

1024, with a dry threshold set at 500. Readings below 500 indicate sufficient moisture, preventing the pump from activating, while readings of 500 or higher signify dry soil, triggering the pump to irrigate.

4.2.3.1 Soil moisture sensor threshold detecting dry soil or wet soil

The test assesses the device's accuracy and responsiveness to these conditions by systematically varying the soil moisture levels. For instance, during the wet soil condition (sensor readings between 0 and 499), the pump should consistently remain off. For the dry soil condition (readings from 500 to 1024), the device's ability to activate the pump reliably and maintain consistent irrigation and will deactivate after 6 second when soil sensor constantly detecting water. Figure 4.10 shows the soil sensor threshold for wet soil. Figure 4.11 shows the soil sensor threshold trigger detect dry soil. Figure 4.12 shows the Blynk interface for water pump activated.

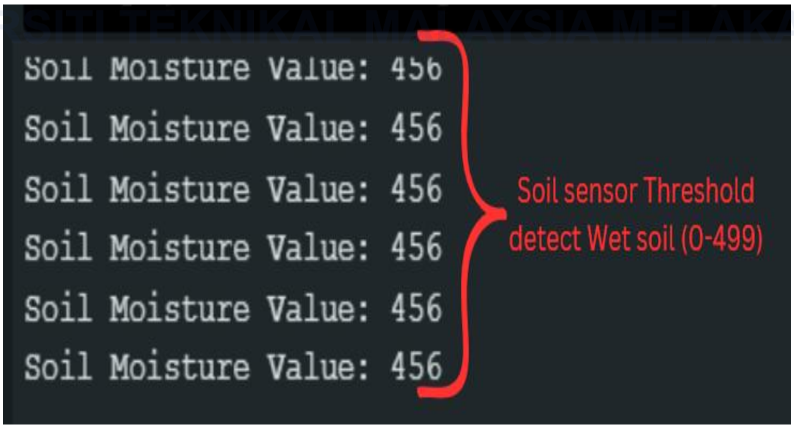


Figure 4.10 Soil sensor threshold for wet soil

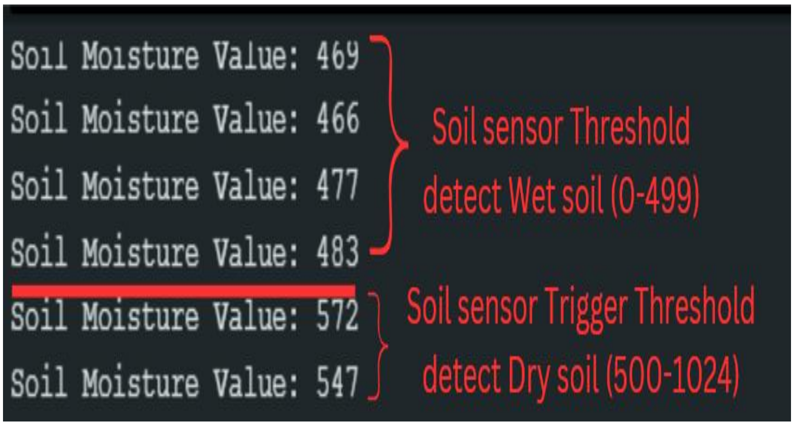


Figure 4.11 Soil sensor threshold trigger detect dry soil

Figure 4.12 Blynk interface for water pump activated

Additionally, the device provides a manual override feature through the Blynk mobile application, which allows users to activate the water pump directly, regardless of the sensor readings. This functionality is particularly useful for scenarios where immediate watering is needed, such as in emergencies, during sensor maintenance The integration of this manual control ensures flexibility and enhances user confidence in the system's ability to adapt to diverse agricultural or gardening needs. By combining automatic responses with manual control, the experiment highlights the system's adaptability and practicality for real-world applications. Figure 4.13 shows manually override to activated water pump.

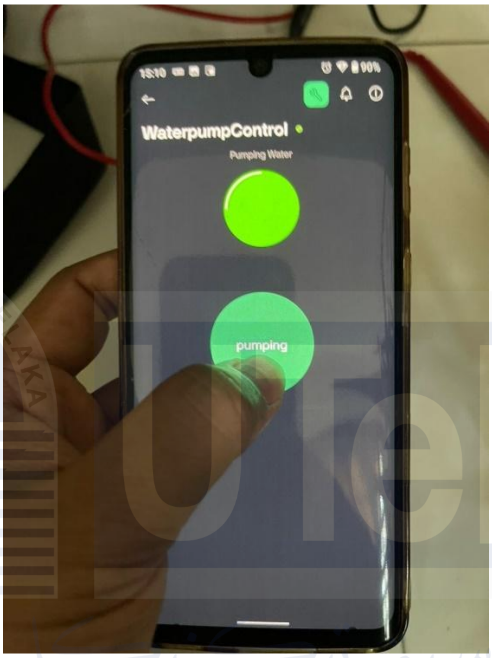


Figure 4.13 Manually override to activated water pump

4.2.3.2 Soil Moisture Sensor Threshold and Device Actions

The device's behaviour based on varying soil moisture conditions. It categorizes sensor readings into two ranges: wet and dry. For wet conditions (0–499), the pump remains deactivated to conserve water and prevent overwatering. For dry conditions (500–1024), the pump activates to irrigate and will automatically deactivate after 6 seconds if the sensor consistently detects moisture. Additionally, the device features a manual override function via the Blynk mobile application, allowing users to activate the pump regardless of sensor readings for greater flexibility and control. Table 4.4 shows the soil moisture sensor threshold and device actions.

Table 4.4 Soil moisture sensor threshold and device actions

Soil condition	Sensor Reading (analog value)	Device Action
Wet	0-499	Pump remains deactivated to prevent overwatering.
Dry	500-1024	Pump activates for irrigation; deactivates after 6 seconds if moisture is detected.
Manual Override	N/A	User can activate the pump via the Blynk app, regardless of sensor readings.

4.3 Summary

This chapter highlights the data collection result through 3 experiments of the project. To give an overview of the Development of IOT based automated plant watering device using photovoltaic solar, measurement reading and calculation were implemented. Furthermore, the anticipated outcomes are specified to explain the intended functionality of the end product. The findings presented in this chapter are primarily derived from complete prototype and software implementation. As the project is completed, its goal is to attain the initial results mentioned and proceed with gathering and analyzing data.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This chapter has provided the initial findings of the development of IOT based automated plant watering device using photovoltaic solar. The prototype models showcased the system's capacity to sustain ideal soil moisture levels. The system guarantees uninterrupted functionality in remote or off-grid locations by harnessing solar energy, thereby promoting environmental sustainability. The utilisation of easily accessible data and resources renders the system uncomplicated to implement and operate in diverse environments.

The system's ability to consistently perform well in various environmental conditions indicates its potential to scale and adapt to different plant care situations. The findings suggest that the development of IOT based automated plant watering device using photovoltaic solar has considerable potential to automated watering plant and resource management. Subsequent efforts will concentrate on advancing the project through hardware implementation, conducting comprehensive field testing, and gathering data to enhance and optimise the system for practical use.

5.2 Project Objective

As mentioned in chapter 1, there are three objectives of this project. For the first objective, related articles have been investigated. The previous work which has been done by other researchers has been analysed and presented in chapter 2 of this project report.

Based on the literature review, a design has been proposed for this project. A system which integrates sensor, microcontroller, and IoT connectivity for remote control and monitoring have been presented well in chapter 3. Next, the second objective has been also achieved for this project, as the proposed system design effectively fulfills the requirements for automated plant watering and monitoring using IoT technology.

The last objective of the project been completed by evaluating the performance of the automated plant watering device powered by photovoltaic solar energy. This evaluation involved assessing its efficiency, reliability, and sustainability in providing a continuous water supply to plants while being energy efficient.

5.3 Recommendations and Future Works

The development of IoT-based automated plant watering device powered by photovoltaic solar energy offers considerable potential for improving agricultural practices. To enhance its effectiveness and applicability, several recommendations are proposed. Firstly, advancements in hardware should be prioritized to improve the device's performance and reliability under diverse environmental conditions. Comprehensive field testing is also essential to collect more extensive data, enabling refinement of the device for various practical applications. Additionally, optimization for diverse use cases, including different plant types and agricultural settings, is crucial to ensure its adaptability. Finally, enhancing the user interface and overall user experience will make the device more accessible and easier to operate for end users. These steps will not only improve the device's functionality but also increase its appeal and adoption.

5.4 Potential of Commercialization

This project demonstrates significant potential for commercialization, largely due to its innovative and sustainable design. By leveraging solar power, the device aligns with global initiatives promoting renewable energy and environmental conservation. Its scalable design makes it suitable for a wide range of applications, from small-scale home gardens to large agricultural operations. Moreover, its ability to conserve water and reduce labor costs positions it as an economical and sustainable solution for modern farming challenges. As a fusion of IoT and renewable energy technologies, this device addresses critical agricultural needs while aligning with emerging trends in smart and sustainable farming. These factors collectively highlight its market viability and promise for broader adoption.

REFERENCES

[1]. Ridwan, Siskandar., Muhammad, A, Fadhil., Billi, Rifa, Kusumah., Irmansyah, Irmansyah., Irzaman, Irzaman. (2020). Internet of things: automatic plant watering system using android. doi: 10.23960/JTEP-L.V9I4.297-310

[2]. Iqlima, Zahari., Bonifacius, Vicky., Wildan, Mahmud., Ichwan, Setiarso., Ivan, Putra, Gemilang. (2023). Utilization of Internet of Things for Automatic Plant Watering System Using Soil Moisture Sensor. JIP (Jurnal Informatika Polinema), doi: 10.33795/jip.v9i2.1220

[3]. Swe, Zin, Kyaw., Zarni, Aung., Kyaw, Swa, Tun. (2020). Implementation and Utilization of Automatic Watering System. doi: 10.52155/IJPSAT.V20.1.1713

[4]. San, San, Lwin., Win, Win, Maw., Yin, Yin, Nu. (2019). Automatic Plant Watering System using Arduino UNO for University Park. International Journal of Trend in Scientific Research and Development, doi: 10.31142/IJTSRD23714

[5]. Ratika, Sekar, Ajeng, Ananingtyas., Ragil, Ellang, Sakti., Muhammad, Helmi, Hakim., Rizka, Rizqi, Robby., Rachmadania, Akbarita. (2023). Design of Automatic Watering System Prototype with Arduino-Based Soil Moisture Sensor for Strawberry Plants (Fragaria Ananassa). Journal of development research, doi: 10.28926/jdr.v7i1.295

[6]. Jabar, H., Yousif., Khaled, Abdalgader. (2022). Experimental and Mathematical Models for Real-Time Monitoring and Auto Watering Using IoT Architecture. Computers, doi: 10.3390/computers11010007

[7]. Maria, Beata, Inka, Astutiningtyas., Monika, Margi, Nugraheni., Suyoto, Suyoto. (2021). Automatic Plants Watering System for Small Garden. International Journal of Interactive Mobile Technologies (ijim), doi: 10.3991/IJIM.V15I02.12803

[8]. Dr., G., Amudha. (2023). Iot-based smart gardening system using arduino uno. Indian Scientific Journal Of Research In Engineering And Management, doi: 10.55041/ijsrem17157

[9]. Dr., Joseph, Merlin, Florrence. (2022). Smart Irrigation System Using IOT. International journal of scientific research in computer science, engineering and information technology, doi: 10.32628/cseit22846

[10]. Mohanad, Abdulhamid., Kimani, Njoroge. (2020). Irrigation system based on Arduino uno microcontroller. doi: 10.5937/POLJTEH2002067A

[11]. Rupali, Saha., R, Shital, Thakre., Sakshi, Khapekar., Shrushti, Newalkar., Sarthak, Nagdeote., Viprant, Moon. (2023). Automatic Plant Watering System. International Journal For Science Technology And Engineering, doi: 10.22214/ijraset.2023.49041

[12]. Jacquline, Morlav, S., Waworundeng., Novian, Chandra, Suseno., Roberth, Ricky, Y, Manaha. (2019). Automatic Watering System for Plants with IoT Monitoring and Notification. doi: 10.31154/COGITO.V4I2.138.316-326

[13]. Prathamesh, Pawar., Aniket, Gawade., Sagar, K., Soni., Sanotsh, Sutar., Harshada, Sonkamble. (2022). IOT Based Smart Plant Monitoring System. International Journal For Science Technology And Engineering, doi: 10.22214/ijraset.2022.42194

[14]. Dr., G., Amudha. (2023). Iot-based smart gardening system using arduino uno. Indian Scientific Journal Of Research In Engineering And Management, doi: 10.55041/ijsrem17157

[15]. Afu, Ichsan, Pradana., Harsanto., Retna, Dewi, Lestari., Rudi, Susanto., Arif, Wicaksono, Septyanto. (2021). Internet Of Things Based Plant Watering System Design.

[16]. Neha, Singh., Shreya, Srivastava., Sana, Mukhtar., Rahul, Mani, Upadhyay. (2020). Arduino based automatic plant watering/irrigation system. 04(12):273-276. doi: 10.33564/IJEAST.2020.V04I12.045

[17]. Lola, Adetia., Sri, Wahyu, Suciyati., Amir, Supriyanto., Gurum, Ahmad, Pauzi. (2022). Soil Moisture Monitoring System Applied to the Internet of Things (IoT) Based Automatic Watering Equipment in Papaya Fields. Journal of Energy, Material, and Instrumentation Technology, 3(2):63-73. doi: 10.23960/jemit.v3i2.99

[18]. Maria, Beata, Inka, Astutiningtyas., Monika, Margi, Nugraheni., Suyoto, Suyoto. (2021). Automatic Plants Watering System for Small Garden. International Journal of Interactive Mobile Technologies (ijim), 15(02):200-207. doi: 10.3991/IJIM.V15I02.12803

[19]. S., Akwu., U., I., Bature., K., I., Jahun., M., A., Baba., A., Y., Nasir. (2020). Automatic plant Irrigation Control System Using Arduino and GSM Module. International Journal of Engineering and Manufacturing, 10(3):12-26. doi: 10.5815/IJEM.2020.03.02

[20]. A., Trihandoyo. (2023). Designing Plant Monitoring System Using Arduino. INTERNATIONAL CONFERENCE ON RESEARCH AND DEVELOPMENT (ICORAD), 2(1):71-80. doi: 10.47841/icorad.v1i2.84

APPENDICES

1. PROJECT CODING

```
#define BLYNK_TEMPLATE_ID "TMPL6DxnzW_8H"

#define BLYNK_TEMPLATE_NAME "WaterpumpControl"

#define BLYNK_AUTH_TOKEN "mjfY4QQ4xPeFvV9rk-CzLVGD2KnWIRf9"


#include <ESP8266WiFi.h>

#include <BlynkSimpleEsp8266.h>


// Replace with your WiFi credentials

char auth[] = "mjfY4QQ4xPeFvV9rk-CzLVGD2KnWIRf9";

char ssid[] = "REAP";

char pass[] = "2404131419";


// Pin Definitions

const int moistureSensorPin = A0; // Analog pin connected to the soil moisture sensor

const int relayPin = D1;          // Digital pin connected to the relay module

const int moistureThreshold = 500; // Adjust based on your soil moisture sensor reading


// Blynk Virtual Pins

#define BUTTON_PIN V0

#define LED_PIN V1
```

```
// Button state to manually control pump
bool pumpState = false;
unsigned long lastPumpTime = 0;
const unsigned long pumpDuration = 6000; // 6 seconds

void setup() {
  // Start Serial for debugging
  Serial.begin(115200);

  // Connect to Wi-Fi
  Blynk.begin(auth, ssid, pass);

  // Pin modes
  pinMode(relayPin, OUTPUT);
  digitalWrite(relayPin, HIGH); // Ensure the relay is off initially
  pinMode(moistureSensorPin, INPUT); // Input for moisture sensor
}

void loop() {
  // Run Blynk process to maintain the connection
  Blynk.run();

  // Read soil moisture sensor value
  int moistureValue = analogRead(moistureSensorPin);
```

```
// Debugging output
Serial.print("Soil Moisture Value: ");
Serial.println(moistureValue);

// Only check moisture and automatically turn on pump if the button has not been pressed
if (!pumpState) {
  // Check if the soil is dry (moisture value above threshold) and enough time has passed
  if (moistureValue > moistureThreshold && millis() - lastPumpTime > pumpDuration) {
    // Turn on the water pump
    digitalWrite(relayPin, LOW); // Relay active, pump on
    Blynk.virtualWrite(LED_PIN, HIGH); // Turn on LED to indicate pump is on

    // Save the current time when the pump is turned on
    lastPumpTime = millis();
  }

  // Check if it's time to turn off the pump (6 seconds have passed)
  if (millis() - lastPumpTime >= pumpDuration && digitalRead(relayPin) == LOW) {
    // Turn off the water pump
    digitalWrite(relayPin, HIGH); // Relay inactive, pump off
    Blynk.virtualWrite(LED_PIN, LOW); // Turn off the LED to indicate pump is off
  }
}

delay(100); // Short delay before the next loop to avoid excessive readings
```

```
}

// Blynk button press function to manually control pump
BLYNK_WRITE(BUTTON_PIN) {
  pumpState = param.asInt(); // 1 for ON, 0 for OFF
  if (pumpState) {
    digitalWrite(relayPin, LOW);  // Turn on the water pump
    Blynk.virtualWrite(LED_PIN, HIGH);  // Turn on LED to indicate pump is on
  } else {
    digitalWrite(relayPin, HIGH); // Turn off the water pump
    Blynk.virtualWrite(LED_PIN, LOW); // Turn off the LED
  }
```