SMARTSEED: IOT-ENABLED GERMINATION KIT FOR INTELLIGENT PLANT GROWTH

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (MAINTENANCE) WITH HONOURS

2025

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical Technology and Engineering

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A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Maintenance) with Honours

Faculty of Mechanical Technology and Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2025

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This project is dedicated to the tireless pursuit of knowledge and the ongoing quest to illuminate the frontiers of my dream. It would not have been possible without the unwavering support of my family, especially my parents. Their unwavering belief in me fueled my motivation throughout this journey. I am also grateful for the encouragement and camaraderie of my friends, who provided a much-needed source of support during challenging moments. Finally, I extend my deepest gratitude to my esteemed lecturer TS. Shikh Ismail Fairus Bin Shikh Zakaria, whose guidance, expertise and dedication to teaching fostered a love of learning and critical thinking within me. Their insightful feedback and encouragement were instrumental in shaping this project.

ABSTRACT

The increasing cost of vegetables and the growing interest in vegetable gardening have led to more people trying hydroponic and fertigation planting activities. Certainly, the utilization of information and communication technology (ICT) is an essential aspect of agriculture to grow its productivity. In this study, we seek to build an IoT system known as IOT-Enabled Germination Kit for Intelligent Plant Growth (SMARTSEED) that can enhance the seed germination for diverse plants. The system vigilantly oversees temperature, air humidity, and soil moisture to maintain ideal conditions tailored to specific crop types. Subsequently, the microcontroller analyses inputs from the sensors and issues commands to activate the pump, guaranteeing precise water delivery to attain the target soil moisture level. Furthermore, UV light activation during nighttime is automated to accelerate the germination process. The performance of the SMARTSEED system was subjected to experiment with specific seed types under controlled and uncontrolled environments. The results were analyzed to justify the effectiveness of SMARTSEED in promoting optimal germination rates compared to traditional methods used for thousand years. This project investigates the potential of IoT-based automation in controlled environments for enhancing seed germination success thus paving the way for advancements in smart agriculture practices.

ABSTRAK

Kos sayur-sayuran dan minat yang semakin meningkat dalam penanaman sayur telah menyebabkan lebih ramai orang mencuba aktiviti penanaman hidroponik dan fertigasi. Sudah tentu, penggunaan teknologi maklumat dan komunikasi (ICT) adalah aspek penting dalam pertanian untuk mengembangkan produktivitinya. Dalam kajian ini, kami berusaha untuk membina sistem IoT yang dikenali sebagai Kit Percambahan Didayakan IOT untuk Pertumbuhan Tumbuhan Pintar (SMARTSEED) yang boleh meningkatkan percambahan benih untuk tumbuhan yang pelbagai. Sistem ini memantau tahap suhu, kelembapan udara dan kelembapan tanah dengan sempurna untuk mengekalkan keadaan ideal yang disesuaikan dengan jenis tanaman tertentu. Selepas itu, mikropengawal menganalisis input daripada sensor dan mengeluarkan arahan untuk mengaktifkan pam, menjamin penghantaran air yang tepat untuk mencapai tahap kelembapan tanah. Tambahan pula, pengaktifan cahaya UV pada waktu malam diautomasikan untuk mempercepatkan proses percambahan. Prestasi sistem SMARTSEED tertakluk kepada percubaan dengan jenis benih tertentu di bawah persekitaran terkawal dan tidak terkawal. Hasilnya dianalisis untuk mewajarkan keberkesanan SMARTSEED dalam menggalakkan kadar percambahan optimum berbanding kaedah tradisional yang digunakan selama ribuan tahun. Projek ini menyiasat potensi automasi berasaskan IoT dalam persekitaran terkawal untuk meningkatkan kejayaan percambahan benih sekali gus membuka jalan bagi kemajuan dalam amalan pertanian pintar.

ACKNOWLEDGEMENTS

Let me start by thanking who has been my supervisor for his support, guidance and care. I am especially grateful to my mentor TS. Shikh Ismail Fairus Bin Shikh Zakaria who have opened up a whole new world for me by giving their invaluable feedback, words of wisdom and compassion along the way.

Another of my debtors is University Teknologi Melaka Malaysia (UTeM) which I had received the financial support from them to complete this project. Since I count the contribution of the other colleagues for the help you made of sharing your ideas and vision for this project.

Hence, my deep gratitude goes to my family, especially to my parents and the other members of the family for their prayer and love.

In the last, but not least, I want to acknowledge the contribution of lecturers at my FTMK campus, my fellow colleagues, secondees in my faculty and all those who did not mention their names of their qualities to be cooperative and helpful.

TABLE OF CONTENS

		PAGE
DECLARATION		
APPROVAL		
DEDICATION		
ABSTRACT		**i**
ABSTRAK		**ii**
ACKNOWLEDGEMENTS		**iii**
TABLE OF CONTENS		**iv**
LIST OF TABLES		**vi**
LIST OF FIGURES		**vii**
LIST OF APPENDICES		**ix**
CHAPTER 1	**INTRODUCTION**	**10**
1.1	Background	10
1.2	Problem Statement	12
1.3	Project Objective	14
1.4	Project Scope	14
CHAPTER 2	**LITERATURE REVIEW**	**16**
2.1	Introduction	16
2.2	Growing Method	17
2.3	Monitoring System	19
	2.3.1 Internet of Thing	19
	2.3.2 Arduino	20
	2.3.3 Raspberry Pi	24
CHAPTER 3	**METHODOLOGY**	**29**
3.1	Introduction	29

3.2 First Milestone 30
3.3 Development of SMARTSEED 31
3.4 Overall Flowchart 31
3.4.1 Wiring Diagram 32
3.4.2 Mechanical Drawing 33
3.4.3 Component Insertion 34
3.4.3.1 Arduino ESP32 35
3.4.3.2 Humidity Sensor 36
3.4.3.3 Transparent Container 37
3.4.3.4 12V Water Pump 37
3.4.3.5 Spray Nozzle 38
3.4.3.6 Ultraviolet LED 39
3.4.3.7 Relay 40
3.4.3.8 Ultrasonic Sensor 41
3.5 SMARTSEED Algorithm Development 42
3.6 Block Diagram 43
3.7 Flowchart of Code Development 44
3.8 System Testing 45
3.9 Cost Expenses 46

CHAPTER 4 RESULTS AND ANALYSIS 48
4.1 Introduction 48
4.2 Prototype 48
4.2.1 Evaluation of Sensors Performance 49
4.2.2 Evaluation of the SMARTSEED 52
4.3 Automated Watering Test 53
4.4 Real-Time Monitoring 53
4.5 Blynk Interface Evaluation 54
4.6 Summary of System Performance 54
4.7 System Development 55
4.8 Coding Development 56
4.9 Cultivation Growth 59
4.10 User Feedback and Review 61

4.11 Summary of Feedback 62
4.12 Discussion 65
4.13 Planning Gantt Chart for PSM 2 67

CHAPTER 5 CONCLUSION AND RECOMMENDATION 68
5.1 Conclusion 68
5.2 Potential Commercialization 68
5.3 Future Works 69

REFERENCES 71

APPENDICES 74

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1	Specifications for Arduino UNO	24
Table 2.2	Specifications for Raspberry Pi 3 Model B	28
Table 3.1	Cost Expenses	47
Table 4.1	Picture of The Sample	50
Table 4.2	Performance of The Sensor	51
Table 4.3	Sensor and Component Performance	52
Table 4.4	Automated Watering System Results	53
Table 4.5	Blynk Interface Evaluation	54
Table 4.6	Daily Growth Measurement	60

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1	An overhead view of a basic germination process	18
Figure 2.2	Basic architecture of an Arduino microcontroller	21
Figure 2.3	Basic Arduino pin diagram	21
Figure 2.4	Arduino UNO pin diagram	22
Figure 2.5	Block diagram of a microprocessor	25
Figure 2.6	Basic component in a Raspberry Pi	25
Figure 2.7	GPIO pin diagram of Raspberry Pi 3 Model B	26
Figure 3.1	Methodology flowchart	29
Figure 3.2	Literature review flowchart	30
Figure 3.3	PSM 1 Gantt Chart	30
Figure 3.4	Flowchart of Hardware Design	32
Figure 3.5	Wiring Diagram	33
Figure 3.6	Mechanical Drawing	34
Figure 3.7	Arduino Uno ESP32 board	36
Figure 3.8	Relative humidity sensor	36
Figure 3.9	Germination Container	37
Figure 3.10	12V Water Pump	38
Figure 3.11	Spray Nozzle	39
Figure 3.12	Ultraviolet LED	40
Figure 3.13	2-Channel 5V Relay Module	41
Figure 3.14	Ultrasonic Sensor	42

Figure 3.15	Arduino IDE logo	43
Figure 3.16	Block Diagram of SMARTSEED	44
Figure 3.17	Flowchart of Code Development	45
Figure 3.18	Analysis flowchart	44
Figure 4.1	Front View of Project Prototype	49
Figure 4.2	First Prototype Development	55
Figure 4.3	Second Prototype Development	55
Figure 4.4	Final Project prototype	56
Figure 4.5	Final Prototype Coding	58
Figure 4.6	Finished Blynk System Dashboard Setup	59
Figure 4.7	Question 1	62
Figure 4.8	Question 2	62
Figure 4.9	Question 3	63
Figure 4.10	Question 4	63
Figure 4.11	Question 5	64
Figure 4.12	Question 6	64
Figure 4.13	Question 7	65
Figure 4.14	Planning Gantt Chart for PSM 2	67

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
APPENDIX A	Full Programming Written in C++ Language	73
APPENDIX B	PSM Research Flowchart	75
APPENDIX C	PSM Gantt Chart	77

CHAPTER 1

INTRODUCTION

1.1 Background

After seed is buried, a process known as germination starts which involves the appearance of a new plant. Lastly, those plants that come into the world through the seeds grow into young plants with irregular numbers of leaves, through the process of seed germination. In the meantime, while the seeds are being sown to facilitate their germination, they nonetheless remain inactive. For germination to take place, there are some requirements that the seeds look for including water, oxygen, hydrology, temperature and light. When these prerequisites come in place, the seeds will be undergoing an expansion process when they intake oxygen and water from surrounding medium. This is followed by germination through a break in the seed coat that facilitates emergence of a root from the seeds then plant shoot emerging. The first phase of the mature plant life that starts with the germination stage is germination. Under the effect of factors that are not always controllable, the desired condition for plants may not be achieved.

However, IoT is the tool that comes into play during this phase. Using IOT, the right environment for seeds germination can be located easily. Anytime the environment deviates from the normal conditions that is, the normal environment explicitly meant for seed germination. Recently, farmers have been growing in knowledge and understanding tackiness and in how seed germination works. In the past studies, they have demonstrated that genetics and molecular biology research is showing immense benefits in seed processing that involve seed germination and enclosure. Industries are using cutting-edge technologies like automatic exhaust fan, highly technical air-conditioning system, space-saving lighting system, smart plant watering machine for getting the process from seed germination happening easily. It is not the ways naturally complies with the norms like these are expensive and effective.

Agriculture of our country most often is dependent on rainfall which influences timely formation of crops to growth, especially at the beginning when seeds form to completion of the planting period as it is the most fragile time in plantation. Climatology started to behave differently as warming process is global. The practical on the ground situation is devastating because of the rain coming as a surprise and storms which are interfering with germination and planting activities quite a lot. However, if this situation continues to be for an extended period of time, then drought may be what will happen to farmers. That is above all the event when seed germination stops to occur. An automatic water system is needed to germinate the seeds which also encompasses all the other attributes that guarantee a successful hatching.

Presently, the number of Agro-farms growing vegetation is limited considering they have a regular operations requirements related to a small portion of land. The approach which their system might require to a sizable surface area, is going to be a costly one and builds on eventual failure as well. Among all the Agro-farming companies in Malaysia, there is one which despite its rational thinking to care only for plantation is spending a lot on germination and planting at a place which is extremely expensive and ineffective in the long run. The Internet of Things (IoT) is a new and emerging technology that seeks to connect any physical devices with computers. In fact, it seeks to allow the exchange of data between the physical devices that are being connected and the computer systems through an interdigitation of one into another. With this technology, there emerges a network between the physical world and computer systems which provide opportunities for decreasing the cost and improving the efficiency.

Hence, automation of crop production process is falling upon the shoulders of the IoT technology. It gives a chance to farmers to control carefully the germination of seeds under favorable conditions. Such a complex method will be to sole a few of basic components with the sensors connected in a way in which we would establish good conditions for seeds germination with higher survival rate of seeds as the result of our work. In this connection, the first part of the goal is to prepare an intelligent system that is based on IoT. A wide range of sensors including temperature, moisture, intensity of light and pH sensor are used to sense minor micro-conditions that favor seed germination. The system is meant to adjust the values so that the individuals that are there are always needed in a way that the seeds will be able to develop.

Translating this into a statement, this study will focus on increasing seed germination across all kinds of plants through lowering in cost and improving efficiency while under a predefined available area. The subsequent part is logically designed in this way. This part describes existing work, where focus is automated system of germination. In this research we will review the system's theoretical design and then its implementation to see how the system works. This research paper will highlight the research methodology including data analysis and evaluation study. In the meantime, those experiences will be share and the summary of the whole lecture are discussed.

1.2 Problem Statement

The rise in vegetable prices has prompted people to seek solutions such as starting home-based hydroponic or fertigation setups. Regardless of this, sowing of seeds kick-starts the growth processes and the technologies used may not often yield tangible outcomes as others that have been in existence in the previous generations. These methods were based on their mechanisms on sustain consistency into the atmosphere conditions including moisture, humidity, temperature and light all of which can be hard to succeed at manually which causes unstable fluctuations and as a result germination failure. Apart, usual approach does not offer the flexibility to be applied for specific varieties.

On the other hand, such as the ones that have a specialized germination system might be less accessible because they are quite expensive and difficult to operate. Many of these solutions are beyond the reach of hobbyists and small scales growers precisely the ones who need the highest germination rates to achieve lasting results that modern farming brings. Broadly speaking, in such cases inventions can continue to suggest automated control systems. However, being adjustable, there will always be a need for human control and monitoring.

This project proposes a novel solution, the Integral role of the Internet of Things in plant growth with the help of SMARTSEED. While the above-mentioned methods may be slow and costly, our system that uses the already-existing IoT technology which is faster and more affordable. SMARTSEED will effectuate the environmental sensors for application to the soil moisture, humidity and temperature transmission of real data on adjustments which are automated. These factors include water, temperature and light etc. These are controlled intelligently by the system with the help of data similar to the pre-programmed information about seeds that are germinated.

Whereas there is usually a certain level of control over the said parameters in regular methods, the SMARTSEED fulfil their responsibilities so that you can expect much higher germination rates than tradition. This automation will bring not just reduction of manhours to set and regulate the system but also put at disposal small-scale growers and hobbyists who will achieve what was thought unachievable in the past. In addition, the data collected by SMARTSEED shall contribute to seed-specific knowledge grow that provides required germination information. Such data will be critical for further progress towards more intelligent cultivation as well as establishing a model world where plants can be grown optimally and in an informed manner.

1.3 Project Objective

The objective of the project are as follows:

a) To design a germination kit system consisting of continues monitoring using IOT for Lactuca Sativa.

b) To provide real-time monitoring and controlled environment for successive plant germination.

c) To evaluate the efficiency of the germination kit and its relevance to potential users.

1.4 Project Scope

The scopes of this work are to build and on a system for smart germination system monitoring with the employed IoT technology to provides efficient and comprehensive intelligent service. In the framework of this technology, we introduce a novel approach that can be used for any plant growing in the germination systems. The project has the following specific scopes:

a) Design and Implementation: construction and running of plant growth containing sensors that can be monitored using IoT technology.

b) Real-Time Monitoring and Control: It is noteworthy to mention that the proposed system will feature real-time monitoring and management of the sustainable germination set up growth condition. This will mean that the plants are fed exact proportions of the nutrients at the turning point of the growth curve.

c) Data-Driven Optimization: In order to carry out scientific experiments for this, it is necessary to determine which environmental conditions best suit different plant species in the germination kit system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Home gardening is in vogue by way of burgeoning gardens fueled by escalating cost of vegetables as reported by Mohamed Farid Noh [1]. Nonetheless, it may be a huge challenge as you try to keep the conditions regulated to suit the needs of lettuce crop and others. A typical conventional approach requires individual tracking of conditions such as humidity, lightening, temperature, and moisture which is a laborious work and can lead to a lot of mistakes. Just minor departure from initial conditions can literally make the process unproductive.

The most effective deep germination systems, such as the ones specially made for certain crop varieties, are often quite expensive and impractical to use at home. Automation would augment but not reduce the job and at the beginning will require more work from the staff because they will have to be retrained to use the system [2].

IoT provides the intelligent data analysis which is vital for environmental sustainability, and it with the combining of automation and real-time data capture technologies, the internet of things offers a very robust solution to create an absolutely closed cultivation system for lettuce growth [3]. Sensors observe crucial variables all the time and bring about settings adjustments immediately, being a pre-set parameter or dynamically modified environment.

View the scenario where there is a busy person who monitors the status of the lettuce remotely using a digital to-do list, employing remote management to maximize the lettuce growth even when the person is away. The technology tagged SMARTSEED which is focused on improving germination success rate as well as a single, simplistic platform where the environmental sensors and automated controls will all be integrated [4].

SMARTSEED intends to do so by pursuing the development of sensor-based agriculture, seed germination, and IoT technology as the forefront of this revolution in how people produce their outdoor lettuce [5]. This article provides the foundation for SMARTSEED system installation, with the aim for higher germination rates and enhanced precision for the home gardeners.

2.2 Growing Method

This sowing constitutes the most fundamental phase in any desirable garden's life cycle as it marks the moment when seeds are set to awaken from their dormant state to new life when a key to a door opens for them. Just as diverse methods of plant fertilizers are vital to the plant growth during its development stage. Diverse methods of germination play an effective role to the seedling emergence success [6] which mean that the harvest for the gardener will be improved.

Two main germination methods empower gardeners sowing and sprouting. Direct seeding means to just drop the seeds into the soil which has already been specially prepared or the soil in a container [7]. For such seeds as do not need a prolonged period dormancy breaking just germinate very easily under warm and moist conditions then this method would be more time advantageous for example, lettuce.

Stratification then imitates the natural cues that are to be followed by seeds to be able to realize that their dormancy has ended. Under this step the temperatures that largely influence dormancy and seedling growth are due to moisture and cold. This is most important for seeds which are lettuce. In cold stratification, the lowest levels of the soil become completely frozen, whereas warm stratification is like warm and high humid conditions which are favorable for germination of some seeds having characteristics for tropical plants or those who want to keep their seeds warm at higher temperatures [8].

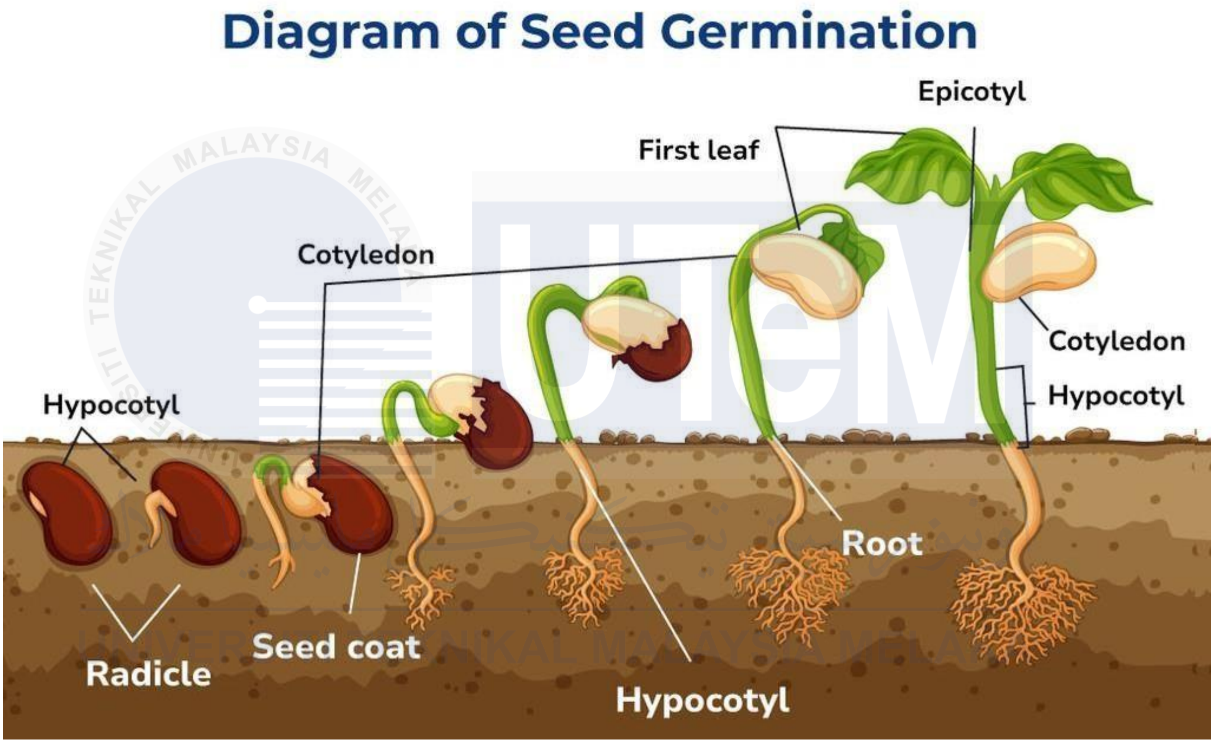


Figure 2.1 An overhead view of a basic germination process

A seed comes alive through germination, a process that starts with water absorption causing the seed to swell and activate internal enzymes. The seed coat splits, the root emerges, followed by shoot growth towards light. As roots strengthen and true leaves develop, the tiny plant becomes a self-sufficient seedling [9].

2.3 Monitoring System

The main goal of smart germination is to use the ICT resources and opportunities, in order to create a virtual ecosystem that safeguards plant health and their surrounding conditions. Sensors carry the initial data load and the process of the system begins with keeping track of various vital factors such as temperature, humidity, water temperature and light levels. One of the studies in Zambia were coordinated with a smartphone on the one side and with farm management system integrated into the devices on the other side [10]. This system together with technologies like Arduino Uno enabled real time tracking and solving up-to-date technology that handles the environmental issues related to crops.

The other study designed an extensive application for the impacted activity of plants in the soil [11]. The app operates on sensors. A control mechanism is established and is automatic. The see how the environment reacts. In device, sensors monitor the parameters in the environment, and some of the properties like moisture, temperature or light amount respond to the stated rules in the sensor type, and this trigger adjustments to maintain the ideal conditions for the plants to grow. Generally, smart germination gives a farmers mean like a Digital Assistant that develops plants optimally as well as increases a farm effectiveness.

2.3.1 Internet of Things

The Internet of things (IoT) has made the concept of connected things a reality and daily objects are being woven into a vast web spanning the digital universe. These gadgets having physical matters while at the same time integrating with sensors, software and other items can now exchange data among themselves. Interoperability and connectivity across internet are made possible due to this [12]. This combined connected network that is built from the foundations of routers, bridges and lots of sensors is also highly crucial in our everyday lives. From triggering interaction with systems, ensuring security, to facilitating communication and triggering automatic action, IoT devices accomplish many complex functions on the basis of targeted goals and also environment needs [13]. Therefore, the IoT empowers ordinary objects by adding intelligence and then they get created and exist in the background to facilitate processes and enhance our lives.

2.3.2 Arduino

Arduino is a very common brand of microcontroller boards among many people. Microcontrollers refer to tiny, low-cost microprocessors which are simply self-contained computers designed for certain applications. Normally, they include a central processing unit (CPU), Read Only Memory (ROM) and Random Access Memory (RAM), input/output ports, etc. all on a single circuit [14]. These microcontrollers get seen on many compact training boards readily and are, thus, tools that are handy for hobbyists and learners.

Arduino microcontrollers have an advantage of power consumption which is usually low, and hence, they can run for long periods on batteries. With a low power usage, they can still provide satisfactory processing speed for they are able to analyses data rapidly. The Arduino's main benefit lies in being a low-cost alternative to the premium microcontrollers [15]. They are able to do analogous actions like sensing of sensors data, monitoring systems and manipulation of embedded systems using Pulse Width Modulation (PWM) for purposes like converter operation.

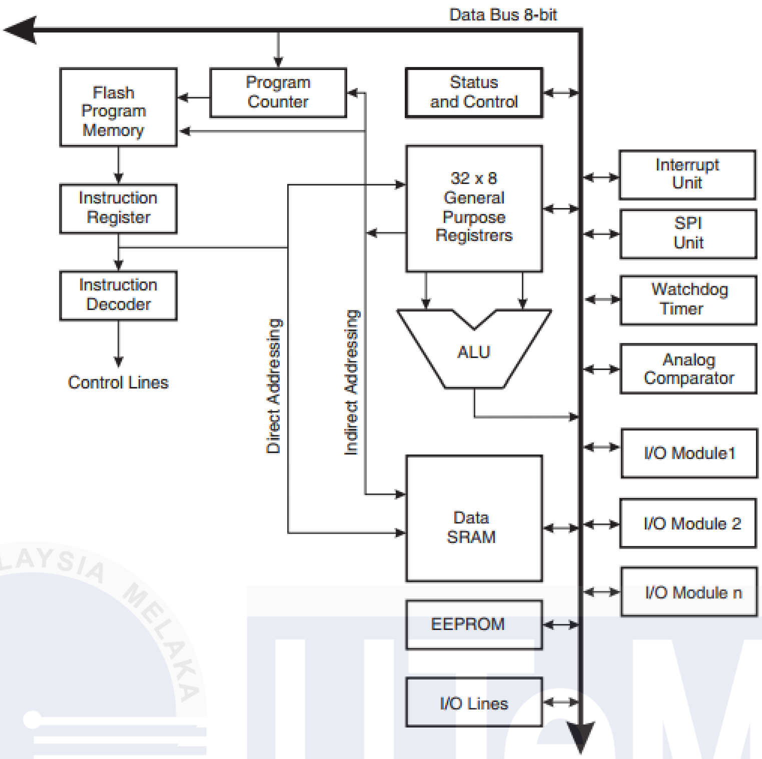


Figure 2.2 Basic architecture of an Arduino microcontroller

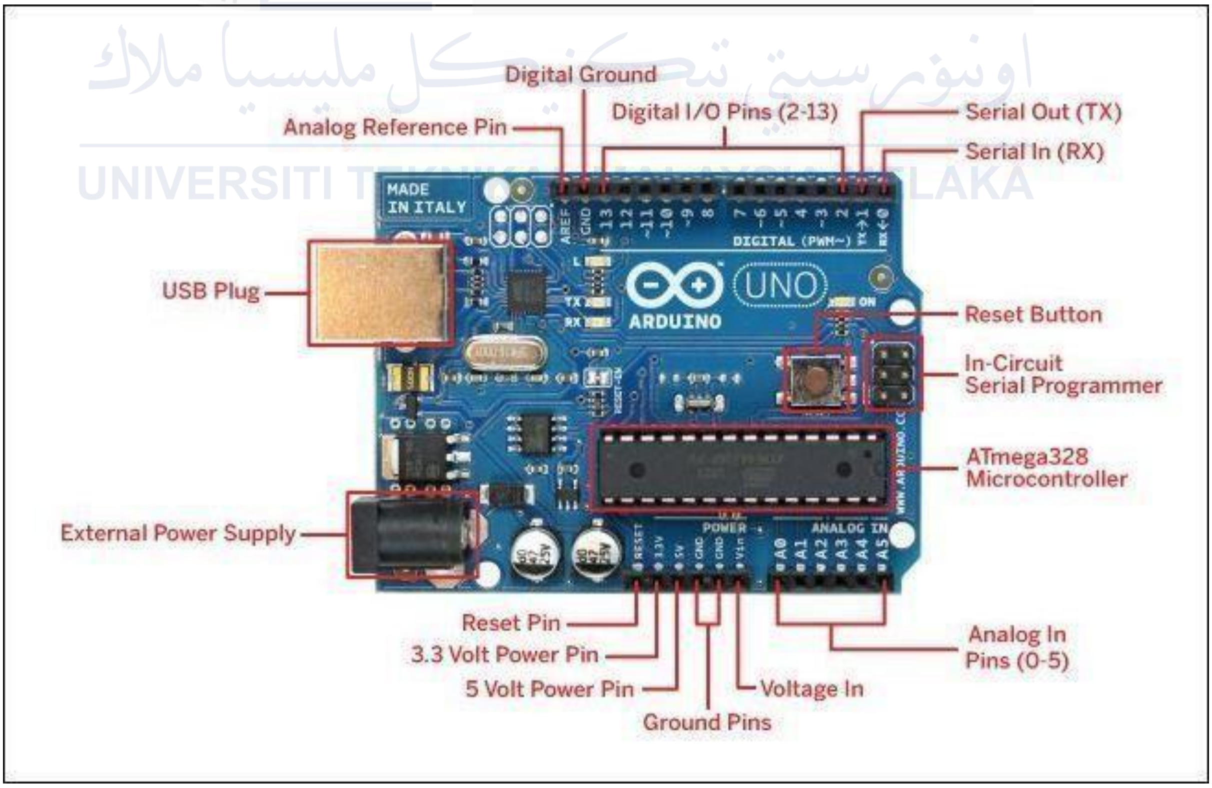


Figure 2.3 Basic Arduino pin diagram

An instance of microcontroller architecture displays the typical Arduino pin layout. Arduino boards could get the information from several sources such as built-in sensors, external sensors, user interaction and even network messages. Input is that treated to microprocessor on board and it changes to the output board can handle [16].

Arduino makes development simpler providing its dedicated programming language and Integrated Development Environment (IDE) software. With such user-friendly software having it is very convenient to designers that require them to create custom applications [17]. The Arduino UNO board which is famous for being beginner-friendly in particular. Its characteristic pin count is now the reference point for many development boards. Therefore, you can link it with a lot of add-on modules.

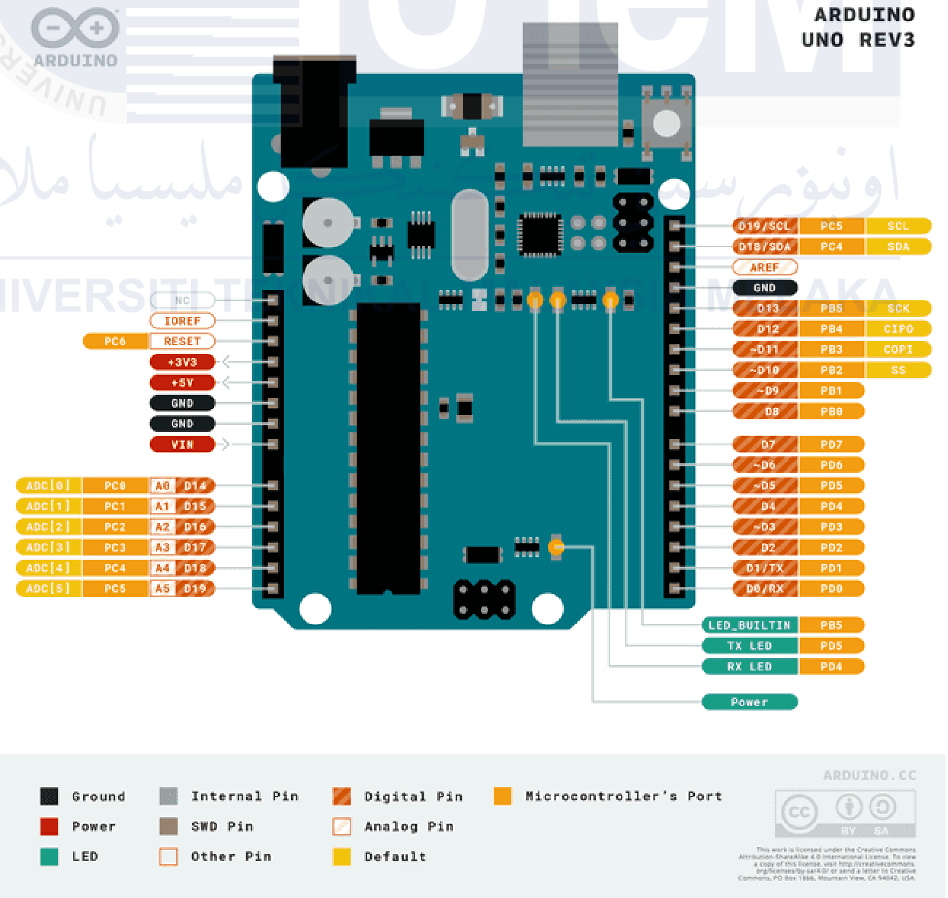


Figure 2.4 Arduino UNO pin diagram

Table 2.1 Specifications for Arduino UNO

Board	
Name	Arduino UNO R3
Sku	A000066
Microcontroller	
ATmega328P	
USB connector	
USB-B	
Pins	
Built-in LED Pin	13
Digital I/O Pins	14
Analog input pins	6
PWM pins	6
Communication	
UART	Yes
I2C	Yes
SPI	yes
Power	
I/O Voltage	5V
Input voltage (nominal)	7-12V
DC Current per I/O Pin	20 mA
Power Supply Connector	Barrel Plug
Clock speed	
Main Processor	ATmega328P 16 MHz

USB-Serial Processor	ATmega16U2 16 MHz
Memory	
ATmega328P	2KB SRAM, 32KB FLASH, 1KB EEPROM
Dimensions	
Weight	25 g
Width	53.4 mm
Length	68.6 mm

2.3.3 Raspberry Pi

While Arduino is the name associated with microcontrollers, Raspberry Pi is a recognized brand of single-board computers. Unlike the microcontrollers produced for certain tasks, the Raspberry Pi is designed to perform as a general-purpose computer. At its core it has a microprocessor the same as in your PC, conducting program instructions and calculating [18].

With the invention of microprocessor in 1970, it has allowed computers to be miniaturized and have lower cost for processing power [19]. This innovation made it possible for PCs and, later, mobile devices to be developed. The Internet-of-things (IoT) is predicted to be the next wave of the computing revolution, and the microprocessor will continue to perform the most critical role [20].

All the pivotal components of a computer such as CPU, GPU, and input/output circuits are crammed onto a single Raspberry Pi board. Compactness and multifunctionality are the key features of the chosen design. The main feature here is the GPIO pins which are widely used. These pins are used to program and interact with electronic parts of a microcontroller, which serve as a medium of information collection and device controlling.

Raspberry Pi in a nutshell is a small computer that fits a credit card and is able to run various programs and involve itself in activities involving calculations and decision-making.

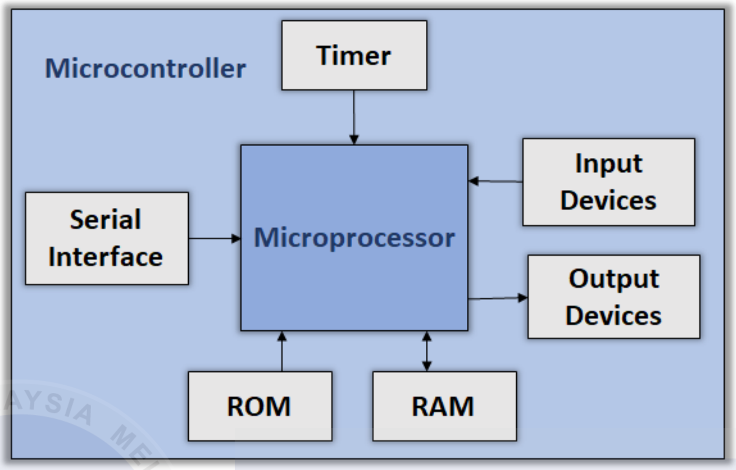


Figure 2.5 Block diagram of a microprocessor

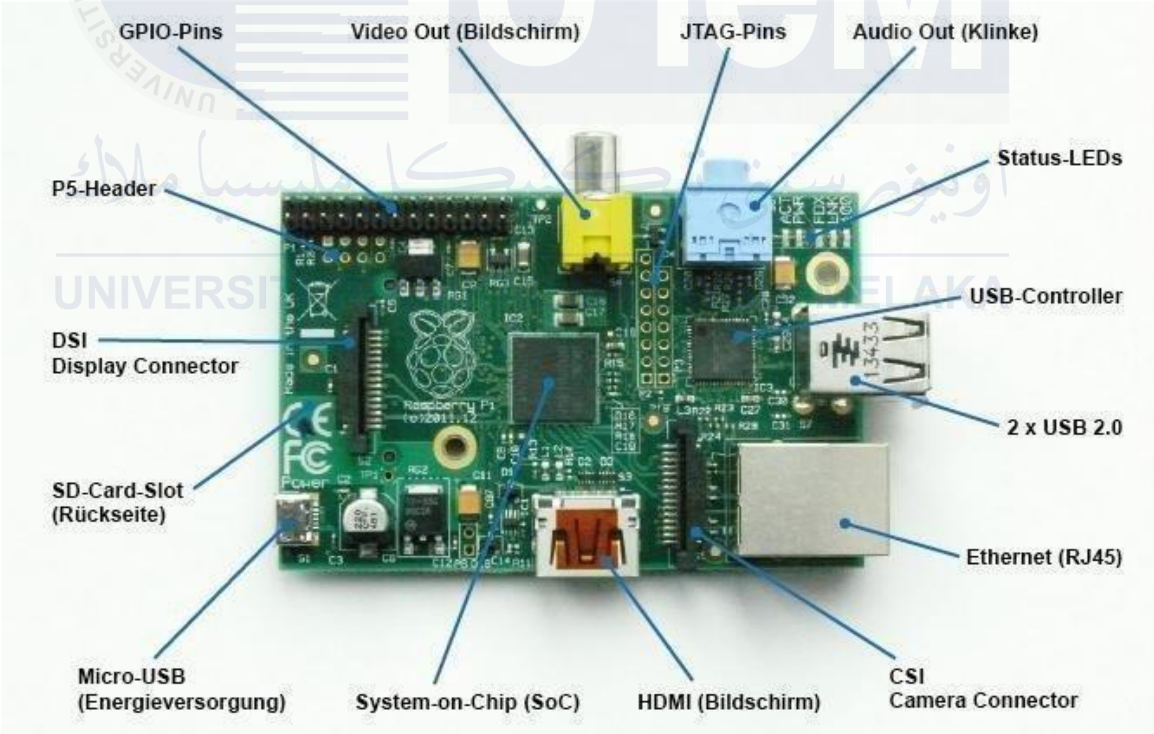


Figure 2.6 Basic component in a Raspberry Pi

Alongside the Raspberry Pi 3, we witnessed a great milestone with the introduction of the first ever 64-bit-chip feature in the series, the Broadcom BCM2837 processor [21]. This column imparted a current of remarkable potency in contrast to the prior editions. Moreover, there was the addition of built-in Wi-Fi and Bluetooth connectivity to the new Pi 3 which in effect was the first model to have such feature.

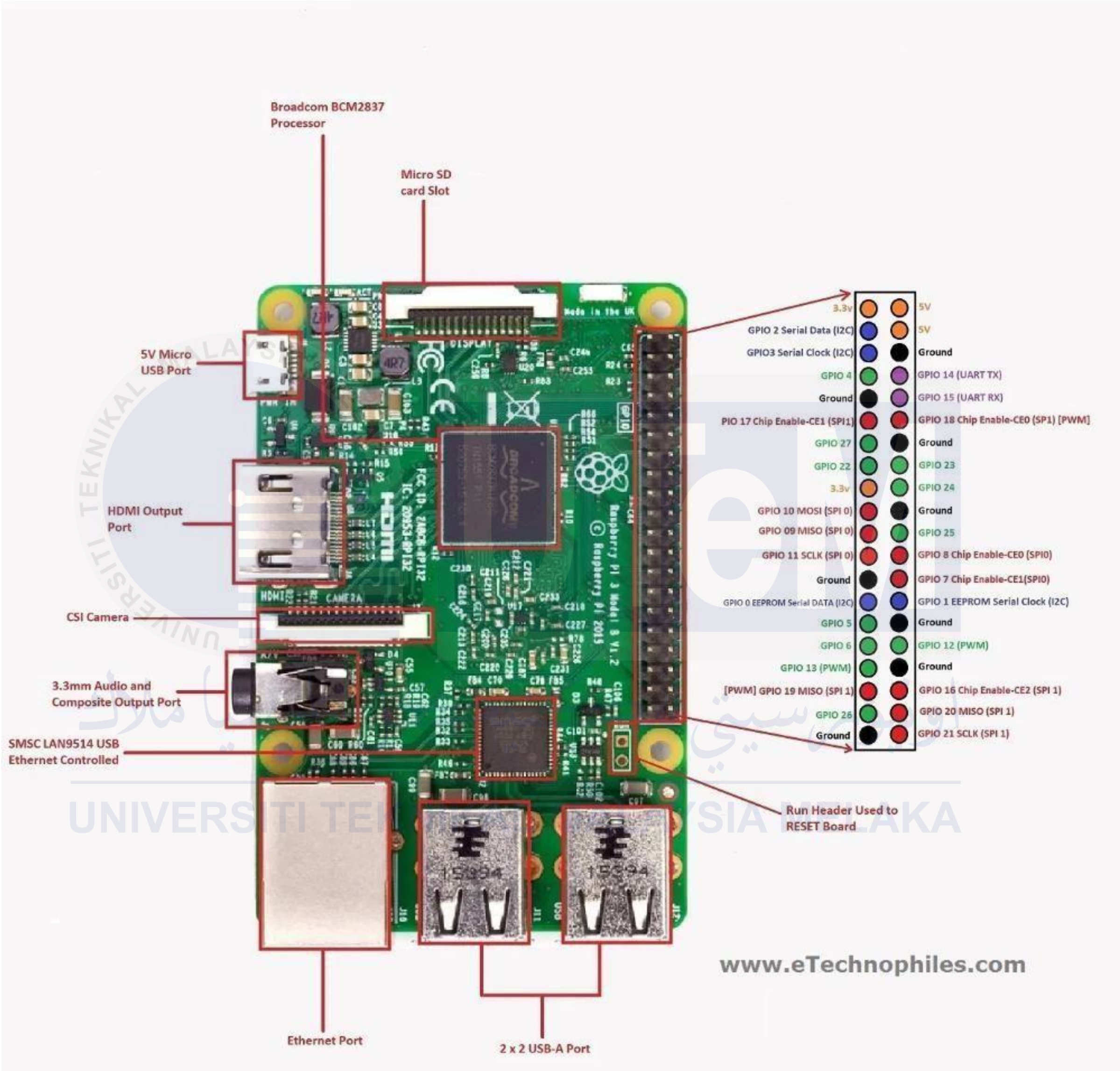


Figure 2.7 GPIO pin diagram of Raspberry Pi 3 Model B

Table 2.2 Specifications for Raspberry Pi 3 Model B

NAME	Raspberry Pi Model B/Raspberry Pi 3B
CHIPSET	Broadcom BCM2837
CPU	1.2GHz quad-core 64-bit ARM cortex A53
OPERATING VOLTAGE	5 V
ETHERNET	10/100 (Max throughput 100Mbps)
USB	Four USB 2.0 with 480Mbps data transfer
STORAGE	MicroSD card or via USB-attached storage
WIRELESS CONNECTIVITY	802.11n Wireless LAN (Peak transmit/receive throughput of 150Mbps) Bluetooth 4.1
GRAPHICS	400MHz VideoCore IV multimedia
MEMORY	1GB LPDDR2-900 SDRAM
EXPENDABILITY	40 general purpose input-output pins
VIDEO	Full HDMI port: Camera interface (CSI) & Display interface (DSI)
AUDIO	Combined 3.5mm audio out jack and composite video

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will involve the general plan and design of the sequence. With the aim of success of the project, the process in designing and creating the controlled automatic nursery will be described in detail. Stage process is separated onto few sections.

Figure 3.1 Methodology flowchart

3.2 First Milestone

To begin with, the supervisor and I had a conversation that revolved around the choice of name, the target, and the overall size of the undertaking. It was the first step in which the project objectives were identified, and then a comprehensive literature search was carried out. The reason for doing the literature review is to get an overall understanding of what is known about the topic, how is it done, which theories are the most scientific, and which discoveries has been made. The existing studies can be evaluated by way of this that the investigators will be able to determine gaps, trends, and the topics that need more thorough study. Afterwards, decide upon the main topics that are required to be execute, and get this permission from supervisor. To wrap this literature study is done by some procedures, which include searching the necessary data on the web using keywords and documents like Google Scholar, ScienceDirect, ResearchGate etc. The most critical point here is to make sure that all the details came from trustworthy sources.

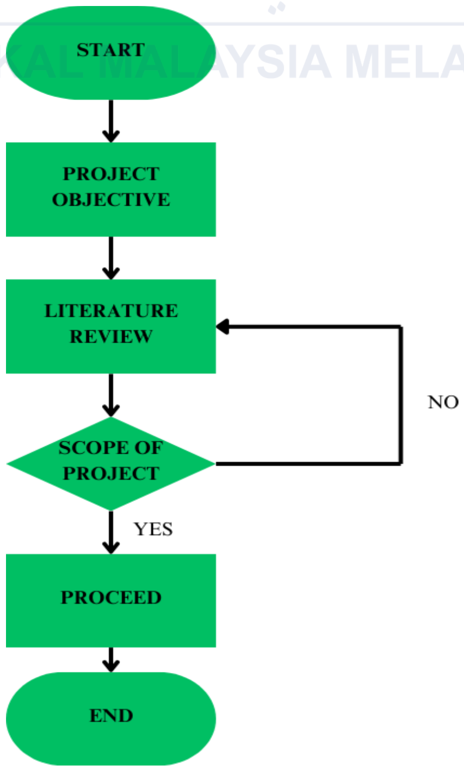


Figure 3.2 Literature review flowchart

3.3 Development Of SMARTSEED: IOT-Enabled Germination Kit for Intelligent Plant Growth

This section will discuss the development of the SMARTSEED: IoT-Enabled Germination Kit for Intelligent Plant Growth. An overall flowchart is required to map out the system's functional environment. The use of the flowchart all through the development process leads to a clear understanding of the system and makes the implementation easier.

3.4 Overall Flowchart

This section will present the overall flowchart of the SMARTSEED: IoT-Enabled Germination Kit for Intelligent Plant Growth, outlining the development process from start to finish. The working procedure is as follows, the first step is the research and idea generation step and then the hardware design step. If the design is considered realistic, the system proceeds to software creation. However, if the design is not feasible then the cycle goes back to the hardware design for more optimization. After the software development process is over, the work of the system is checked. Incompatibility between software and hardware is resolved during the software development process if it is discovered. On the other hand, if the software and hardware are compatible, the system is validated in order to check whether the system complies with the set specifications. If the requirements are met, the process continues to documentation. If not, the cycle goes back to the hardware design phase of the development life cycle of a product.

In conclusion, this overall flowchart offers a big picture of the project's progression and acts as a reference to what actions to take and what decisions to make in case of encountering some obstacles. The flowchart is easily expandable with smaller flowcharts for each stage of the process in order to better explore each step. The general flowchart of the development of the SMARTSEED system is shown in figure 3.4.

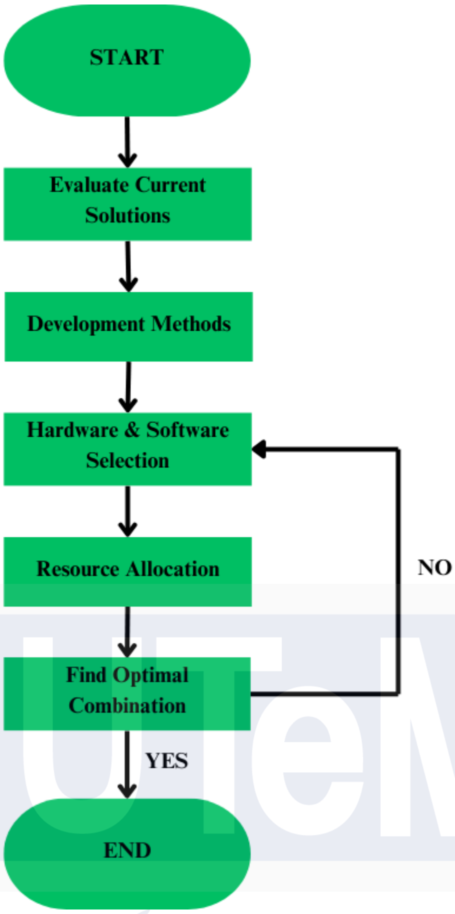


Figure 3.4 Flowchart of Hardware Design

3.4.1 Wiring Diagram

In our SMARTSEED: IoT-Enabled Germination Kit project, various components are connected to the ESP32 microcontroller to ensure optimal functionality. Figure 4.1 will show the wiring configuration of the SMARTSEED system. These components consist of the following, a DHT22 temperature and humidity sensor for monitoring the temperatures and humidity of the environment together with the soil moisture sensor to test the condition of the soil, an ultrasonic water level sensor for measuring water levels. The system also incorporates a submersible water pump for watering, UV LEDs for regulating light intensity and relays to operate apparatus. Thus, we have achieved an optimal layout and wiring of these components to incorporate an effective and easily operated smart germination system.

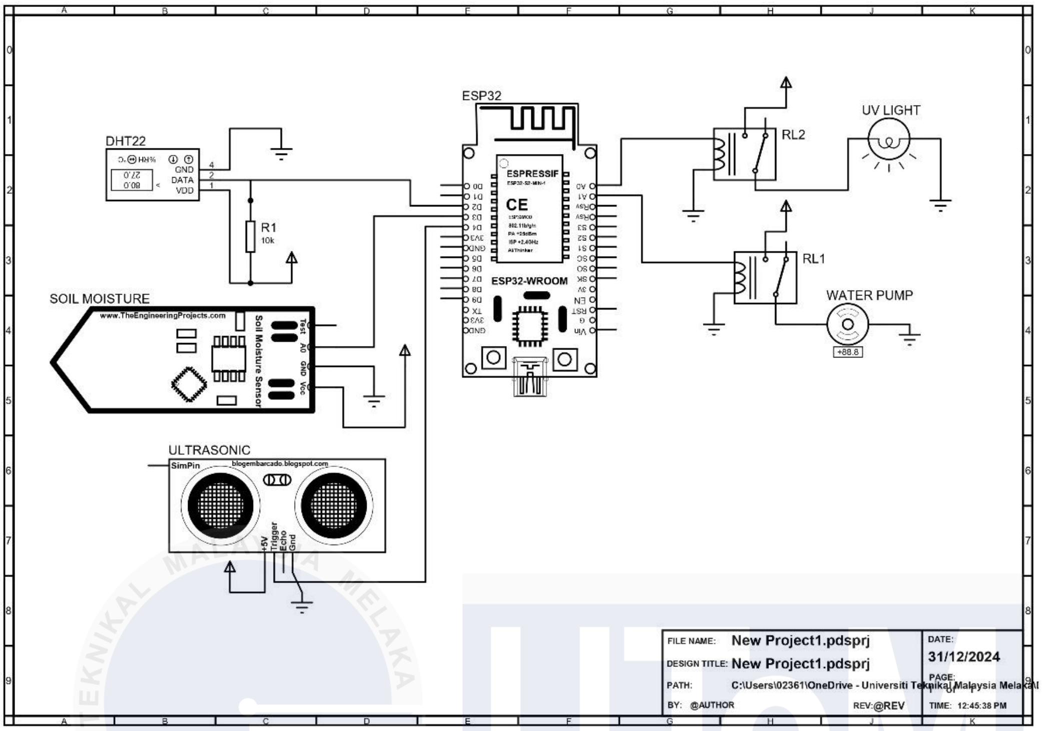


Figure 3.5 Wiring Diagram

3.4.2 Mechanical Drawing

Mechanical drawings are very essential at the stages of the SMARTSEED prototype development since they offer a physical layout of the envisaged design, as we shall see in the following section. This section focuses on presenting the comprehensive layout of the SMARTSEED: IoT-Enabled Germination Kit. The mechanical drawing illustrates how the system should look like in terms of how the different components should be disposed. It facilitates the assessment of viability and efficiency of the design idea on the building project. Looking at the mechanical drawing we are able to come up with a clear notion on how each component of the germination kit works in unison.

It helps in finding out whether there is any shortfall or weak design and thus before constructing the prototype of the product. The mechanical drawing also plays the role of determining the formation of the design to enable efficient use. Mechanical drawing of the SMARTSEED system is illustrated in figure 3.4 below. The parts are soil moisture sensor, UV LEDs, water pump and DHT22. The microcontroller, a breadboard along with the wiring and the power supply unit, ESP32, are mounted in a precisely designed manner depending on the neatness required and shielding of the components to avoid injury or accidental connection to an incorrect pin. The water pump and spray nozzle provide a perfect control with the process of watering the seeds, whereas UV LEDs facilitate correct germination by supplying the seeds with the required amount of light.

In general, the presented mechanical drawing can be seen as an effective mean in the initial phase of the work, which in fact provides a solid basis for the visualization and prototyping of the SMARTSEED system.

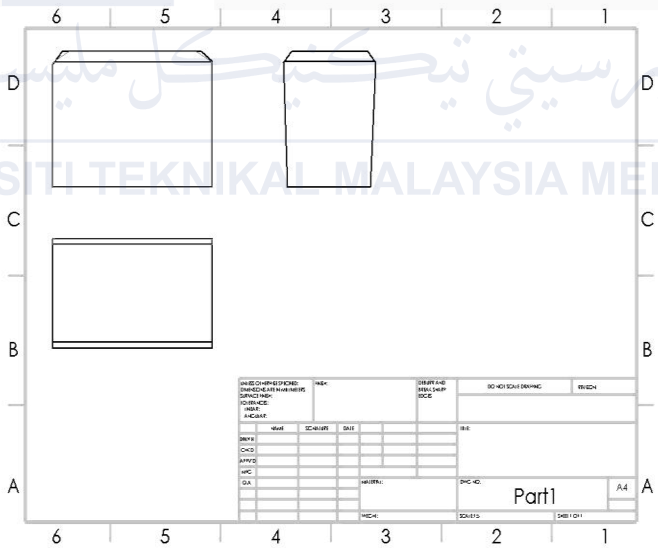


Figure 3.6 Mechanical Drawing

3.4.3 Component Insertion

This section will discuss the development of the SMARTSEED: IoT-Enabled Germination Kit for Intelligent Plant Growth. Each hardware component and software tool will be thoroughly explained to provide a comprehensive understanding of their functions and roles within the project. By exploring the hardware, such as sensors, the water pump, UV LEDs, and the ESP32 microcontroller, we can understand how these components interact and contribute to the system's overall functionality.

Additionally, the software aspects will be covered, including the programming languages, libraries, and frameworks used to control and coordinate the hardware components. Tools such as the Arduino IDE, Blynk dashboard, and C++ programming language enable seamless integration and precise control over the system. Understanding the capabilities and functionalities of both the hardware and software ensures informed decision-making and smooth project development. This approach ensures that SMARTSEED achieves its goal of providing an efficient and user-friendly solution for intelligent plant germination.

3.4.3.1 Arduino ESP32

Arduino ESP32 combines the user-friendly Arduino interface with the muscle of the ESP32 chip, making it a popular choice for building internet-connected devices (IoT). For those new to electronics. Arduino's strength lies in its simplicity and accessibility. Imagine a large, supportive community and a development environment that feels like familiar territory that's the Arduino advantage. Plus, there's a treasure trove of pre-written code for various components saving time and effort. The ESP32 chip adds some serious muscle to the mix. Unlike basic Arduinos, ESP32 boasts built-in Wi-Fi and Bluetooth, allowing your projects to connect to the internet or other devices wirelessly. It also packs a bigger punch in terms of processing power and memory, making it suitable for complex IoT tasks. The ESP32 is known for being battery-friendly. So, Arduino ESP32 offers the perfect blend of beginner-friendly development and powerful hardware, empowering to create innovative internet-connected projects.

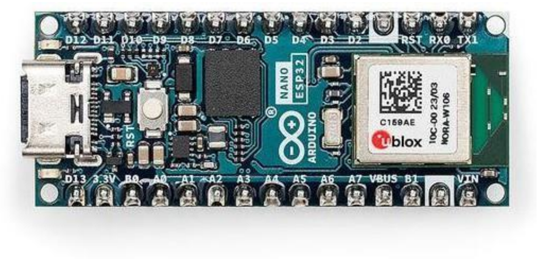


Figure 3.7 Arduino Uno ESP32 board

3.4.3.2 Humidity Sensor

Some germination kits have a little sensor that sense humidity. This sensor employs smart methods like monitoring electrical activity or material resistance to determine the amount of moisture present in the air. Thus, the kit looks into this data and decides if the humidity level is suitable for your seeds. Many sprout seeds remain dormant until they perceive a specific ambient humidity and this sensor helps you to track these changes. Apart from this mold can emerge in areas with high humidity, but the sensor will warn you about this kind of danger zone so that you can respond to it accordingly. Actually, this small sensor is huge in contributing to the ideal conditions for your seeds to germinate successfully.

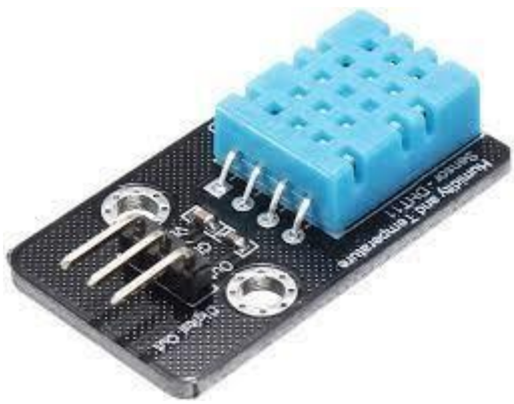


Figure 3.8 Relative humidity sensor

3.4.3.3 Transparent Container

Germination kits often utilize see-through containers for their clear advantages. This transparency allows you to easily observe the germination process without disturbing the seeds. You can watch root development, sprouting, and even identify problems like mold growth early on. Additionally, sunlight, crucial for many seeds to germinate, can pass through the walls, reaching the seeds directly. However, some seeds might require light control, so the container might have designated covered areas. Finally, the see-through nature helps you monitor moisture levels. By observing condensation inside, you can assess if the environment is too dry or if there's excess moisture that might need ventilation.

Figure 3.9 Germination container

3.4.3.4 12V Water Pump

The 12-volt water pump in the germination kit provides a constant moisture system for your young plants. Picture a set-up where the kit's water is being quietly spurred by a miniature horse. This helps the sprouting plants to develop strong roots by keeping the substrate (for example sponges or rockwool) moist. This feature makes it energy-efficient and safe to use at home because of its low voltage (usually 12 volts). The design of germination kit is going to decide the exact size and method of pumps so watering the seedlings automatically will be easy and smooth.

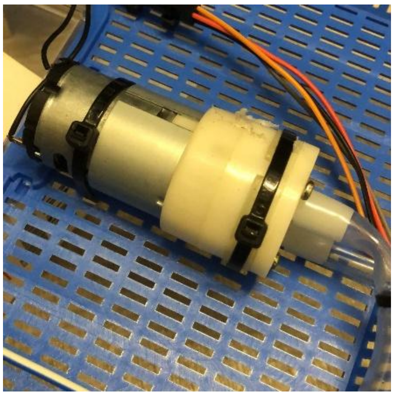


Figure 3.10 12V water pump

3.4.3.5 Spray Nozzle

A simple sprinkler which will highly act in union with a 12-volt water pump will accelerate the process of seed germination. Through atomizer water flow the leaves of young seedling plants are protected from desiccation due to constant soft mist that is formed. Two key benefits come with this targeted misting: it does this by the first way controlling the moisture properly. High velocity sprays are very susceptible to tear up seedlings or letting water pass in excess into the growing medium. The atomized spray ensures the right quantity of moisture medium in three hydroponic-balanced solution for seedlings without risking the protection of the plant. In second misting increases humidity and thus the moisture level too. This is adjusted humidity that mimic the one fundamental part of the natural environment which comes with the seeds germination and this process usually set in high humidity levels. This way of keeping the moisture in the seeds team up with the effort of simulating the natural condition and climate to assure the good germination.

Figure 3.11 Spray nozzle

3.4.3.6 Ultraviolet LED.

Sunlight has always been a farmer’s regular pointer to healthy crops but with UV LEDs it can slowly but steadily proving to be a useful tool that one can program to behave in a particular way. UV-A light at low intensity is nearly like natural light in that the container can trigger germination of seeds then enhances strong seedling development. Moreover, the certain parts of the UV spectrum can even push plants towards the desired characteristics, such as increased stem thickness, better branching, and even the formation of new flowers. It does not end with the plants, as UV-C light serves as a germicidal tool that kills many germs on plants and perhaps pest infested surfaces hence improving the environment in the growth of plants. Consequently, the application of UV LEDs proves potential in appealing to the farmers by improving germination rate and plant health, as well as increasing possible yield.

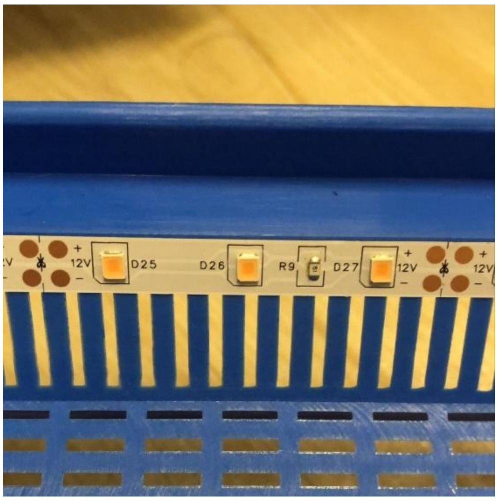


Figure 3.12 Ultraviolet LED

3.4.3.7 Relay

In the field of electrical engineering, the relay plays an important role as an electromechanical switch. It works by converting a small or low voltage signal such as one from a microcontroller or a sensor into the switching on or off of large or high voltage circuits. Therefore, the relay works as an interface that ensures the regulation of powerful electrical components such as motors, solenoids or lamps using comparatively weaker control signal. In particular, this capability is useful in contexts where precise control of complex systems entails the management of highly effective tools. Using a relay, even an infinitesimal amount of electrical current can have a significant impact, making high amperage components work. As such, the relay is a critical component in complex electrical circuits, acting as a link and controlling the flow of this project.

Figure 3.13 2-channel 5V relay module

3.4.3.8 Ultrasonic Sensor

In the realm of liquid level measurement, ultrasonic sensors emerge as a sophisticated tool, offering a non-intrusive and highly accurate approach. Unlike traditional methods that rely on physical contact or visual cues, these ingenious devices harness the power of sound waves to precisely determine the distance to a liquid surface. Imagine a tiny microphone and speaker working in perfect harmony, the ultrasonic sensor emits a high-frequency sound wave that travels outwards like ripples in a pond. This sound wave then encounters the liquid surface and bounces back, just like an echo. The sensor, acting as both sender and receiver, meticulously measures the time it takes for the sound wave to complete its round trip. By analyzing this time difference, the sensor can then calculate the distance between itself and the liquid surface with exceptional accuracy. This remarkable capability makes ultrasonic sensors ideal for measuring the level of various liquids, from crystal-clear water to complex mixture solutions, all within a container. Unlike cumbersome probes or intrusive floats, ultrasonic sensors operate without ever coming into physical contact with the liquid, ensuring a clean and reliable measurement process.

Figure 3.14 Ultrasonic sensor

3.5 SMARTSEED Algorithm Development

The Arduino Integrated Development Environment, IDE, is a multifunctional software application specifically designed to support coding and creating projects with ESP32 and similar boards. The software puts the detailed instructions of the ESP32 into a format that is easy for both novices and experts to write, compile and upload code.

Some of the features include highlighting of code, auto completion of code statements, a package manager to access several already coded libraries among others. Further, it consists of a serial monitor, which is very helpful for debugging and observing live communion between the ESP32 and a computer.

It supports C/C++ language programming and with the project requirements of the SMARTSEED system of integrating complex control logic this is feasible. Used as an editor for programming the microcontroller, as well as for debugging and re-programming, the Arduino IDE provides a strong arsenal of features that helps users of the SMARTSEED system translate innovative concepts into tangible solutions effectively.

Figure 3.15 Arduino IDE logo

3.6 Block Diagram

Before algorithm development for the SMARTSEED: IoT-Enabled Germination Kit, a block diagram is essential to visualize the system's overall architecture and flow. This diagram helps in planning and designing the system's structure, making it easier to identify components and their interactions.

The figure below illustrates the block diagram of the SMARTSEED system. When the sensors collect data, the DHT22 measures temperature and humidity, the soil moisture sensor assesses soil conditions, and the ultrasonic sensor monitors water levels. These sensors send their readings to the ESP32 microcontroller, which processes the input data.

Based on the sensor data, the ESP32 triggers specific actions. For instance, if soil moisture is low, the ESP32 activates the relay to power the water pump, ensuring precise irrigation. Similarly, during nighttime, the ESP32 switches on the UV LEDs to optimize light exposure for germination. The ESP32 also communicates with the Blynk dashboard, allowing real-time monitoring and control through a smartphone.

The ESP32 microcontroller manages the system's overall functionality while ensuring seamless integration between components, such as sensors, actuators, and the cloud-based interface. This block diagram provides a clear understanding of the system's workflow, enabling effective algorithm development and efficient system operation.

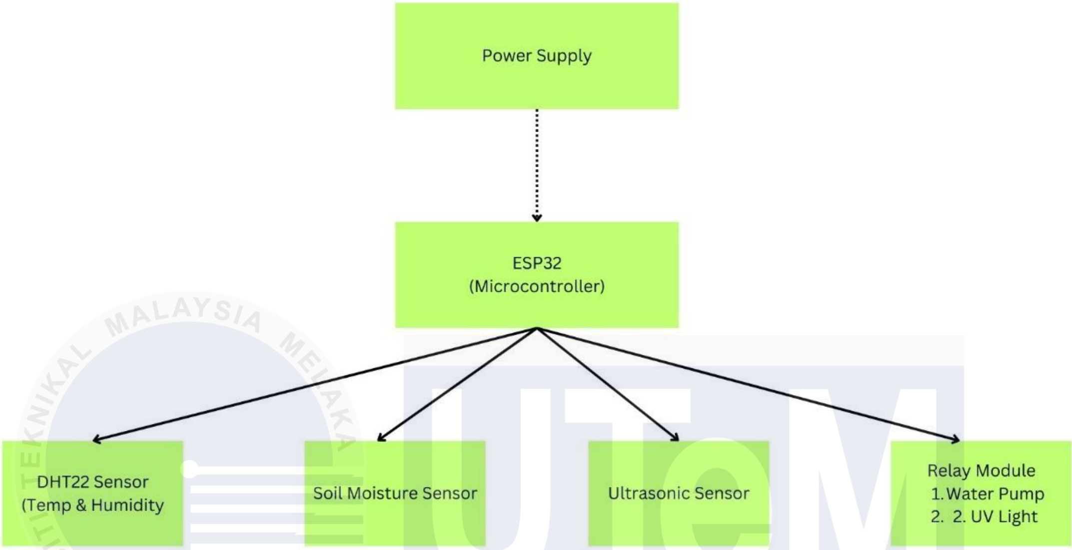


Figure 3.16 Block Diagram of IoT-Enabled Germination Kit for Intelligent Plant Growth

3.7 Flowchart of Code Development

To initiate the development of the code for the SMARTSEED: IoT-Enabled Germination Kit, we begin by including the required libraries, which provide essential functionalities for the project. Next, we define the necessary pins and variables to establish connections with the hardware components and store real-time data.

The subsequent step involves configuring the system by initializing sensor inputs, such as the DHT22 for temperature and humidity, the soil moisture sensor, and the ultrasonic sensor for water level monitoring. Each sensor is carefully calibrated to ensure accurate data acquisition. If any inconsistencies are detected in sensor readings, we revisit the sensor configuration to make the necessary corrections.

The system's output is controlled through components such as the water pump and UV LEDs, managed by relays and the ESP32 microcontroller. After setting the desired parameters for each output, we observe the system's actions, such as the activation of the water pump for irrigation or the UV LEDs for supplemental lighting. If the output behavior deviates from expectations, adjustments are made to the configuration to ensure the desired outcome.

Upon completing these steps and verifying that all components of the code function seamlessly, we can confidently affirm the success of the code development process, ensuring the SMARTSEED system operates efficiently and meets its intended objectives.

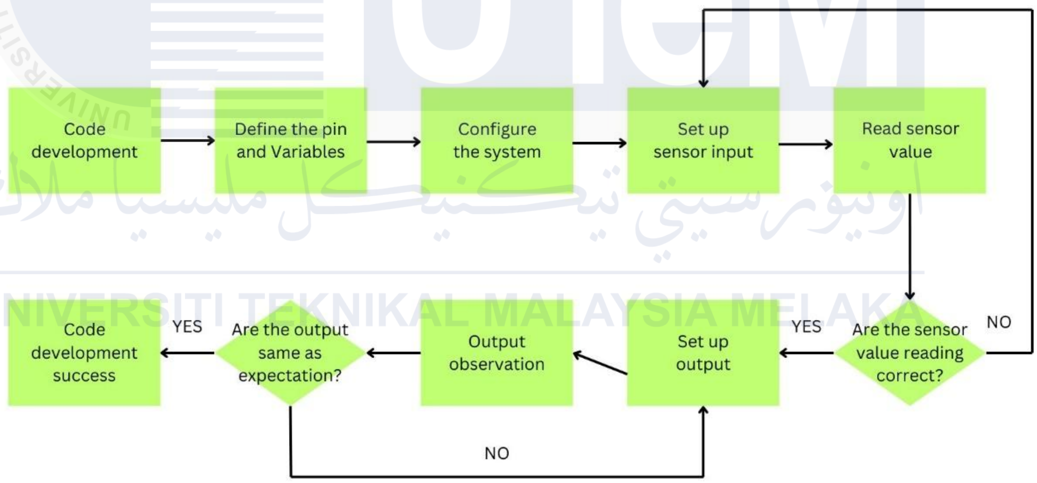


Figure 3.17 Flowchart of Code Development

3.8 System Testing

The system testing phase represents the final step in the development process of the SMARTSEED: IoT-Enabled Germination Kit. During this stage, hardware components are integrated with the developed code to ensure seamless operation of the system.

To initiate testing, Lactuca Sativa (lettuce) seeds are placed into the system under controlled conditions. The sensors play a crucial role in monitoring key environmental parameters: the DHT22 sensor measures temperature and humidity, the soil moisture sensor assesses soil conditions, and the ultrasonic sensor monitors water levels.

When the sensors detect environmental conditions that deviate from the optimal range, the system takes automated action. For instance, if the soil moisture is below the desired level, the water pump activates, delivering precise irrigation through the spray nozzle. Similarly, during nighttime, UV LEDs are activated to provide supplemental lighting, enhancing the germination process.

The system’s microcontroller, the ESP32, coordinates these operations based on real-time sensor data, ensuring that optimal conditions are maintained. The results from these tests validate the system's ability to create an ideal germination environment, ensuring efficient and reliable growth of healthy seedlings. Any deviations or malfunctions identified during testing are addressed to refine the system's performance further. This testing phase is crucial to confirm the SMARTSEED system's functionality and effectiveness in achieving its intended objectives.

3.9 Cost Expenses

This section provides a detailed overview of the financial aspects of the SMARTSEED: IoT-Enabled Germination Kit, focusing on its cost. Understanding these expenses is critical for ensuring transparency and making informed strategic decisions. The table below outlines a breakdown of costs, including quantities, unit prices, and total expenditures for each component used in the project. This financial analysis helps identify opportunities for cost optimization and efficiency, thereby contributing to the overall success and sustainability of the SMARTSEED system.

Table 3.1 Cost Expenses

Item No.	Item Name	Quantity	Unit Cost (RM)	Total Cost (RM)
1	Ultrasonic	1	6	6
2	Soil Moisture	1	10	10
3	Relay Module	1	12	12
4	LDR	1	1	1
5	Water Pump 12V	1	15	15
6	Breadboard	1	6	6
7	DHT22 Humidity & Temp Module	1	25	25
8	ESP32 30P Expansion Board	1	18	18
9	NodeMCU ESP-32 WIFI/BLE/2IN1	1	35	35
10	1CH 5V/12V Relay Module	2	10	20
11	LED Colour 3mm/5mm	1	0.3	0.3
12	Water Pump Sub DC5V	1	15	15
13	Tube	1	2	2
14	DC12V 2A Adaptor	1	23	23
15	1/0.5mm Single Core Cable	2	3	6
Total				**194.3**

CHAPTER 4

RESULT AND ANALYSIS

4.1 Introduction

This chapter discusses the development, testing, and analysis of the SMARTSEED: Smart Plant Growth Kit Through IoT. The results are restricted to the aspects of electronic development, system integration, coding implementation, and plant cultivation experiments. In line with this objective, data analysis is used to assess the extent to which the SMARTSEED system has helped to increase germination of seeds and control the conditions under which growth takes place.

4.2 Prototype

The prototype system for the SMARTSEED: IoT-Enabled Germination Kit comprises an ESP32 microcontroller, DHT22 temperature and humidity sensor, soil moisture sensor, ultrasonic sensor, UV LEDs, a submersible water pump, and a 2-channel relay module. The system is powered by a 12V DC adapter for the water pump and a 5V DC adapter for the ESP32 and sensors.

The enclosure for the prototype is designed to neatly house all components and wiring, ensuring a tidy appearance and protecting the hardware from external damage. The compact design measures approximately 35cm x 20cm x 24 cm, optimized for portability and efficiency.

Figure 4.1 illustrates the completed prototype of the SMARTSEED system, highlighting the integration of its components into a cohesive unit. This prototype demonstrates the system's capability to monitor environmental parameters, automate irrigation and UV light management, and provide a smart solution for efficient plant germination.

Figure 4.1 Front View of Project Prototype

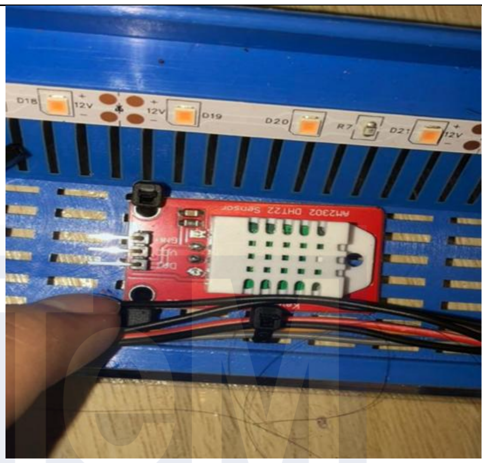
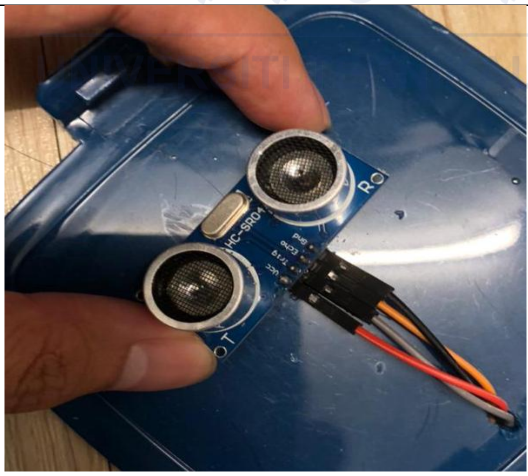
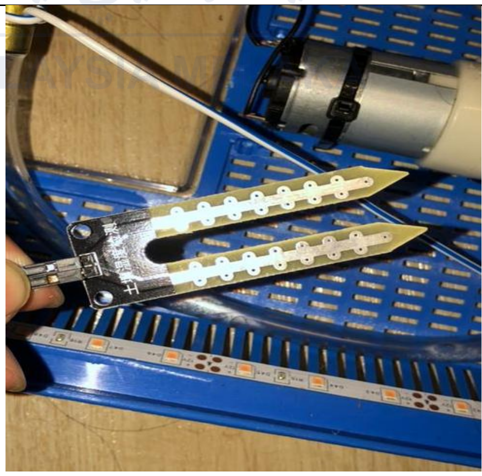
4.2.1 Evaluation of Sensors Performance

This section presents the outcomes of the sensor readings in the SMARTSEED: IoT-Enabled Germination Kit. A HIGH result indicates that the sensor has detected the required condition, while a LOW result signifies that the condition is not met. Each sensor undergoes multiple trials to ensure accuracy and reliability of the data.

Table 4.1 outlines the samples used to evaluate the performance of the sensors, including the DHT22 for temperature and humidity, the soil moisture sensor for soil conditions, and the ultrasonic sensor for water level monitoring. Each sensor is tested under varying environmental conditions, and their responsiveness and accuracy are recorded per scenario.

This systematic evaluation ensures that the SMARTSEED system operates reliably under different conditions, providing precise and consistent data for optimal plant germination.

Table 4.1 Pictures of the Sample

 LDR Sensor	 DHT22 Sensor
 Ultrasonic Sensor	 Soil Moisture Sensor

This is the evaluation of the performance of the sensors utilized in the SMARTSEED: IoT-Enabled Germination Kit. The soil moisture sensor plays a crucial role in assessing the moisture levels of the soil and activating the irrigation system when the levels drop below the optimal range, ensuring consistent hydration. The DHT22 sensor provides precise monitoring of temperature and humidity, maintaining an environment conducive to germination by delivering accurate data for environmental adjustments. Additionally, the ultrasonic sensor effectively measures water levels in the reservoir, ensuring the irrigation system functions reliably and efficiently. Together, these sensors form the backbone of the SMARTSEED system, ensuring its ability to maintain optimal conditions for seed germination and growth.

Table 4.2 Performance of The Sensor

Sensor Type	Set Point Value	Output Voltage	Detection
DHT22 Sensor	60% RH	3.3V	High
Ultrasonic Sensor	20 cm	5V	High
Soil Moisture Sensor	20%	3.3V	High
LDR Sensor	500 LUX	5V	High

4.2.2 Evaluation of the SMARTSEED: IoT-Enabled Germination Kit.

In order to create a robust and efficient irrigation system, a submersible water pump is strategically deployed. This dependable workhorse resides beneath the water's surface, silently drawing upon its reserves to fulfil a vital purpose. Its primary function is to meticulously transport life-giving water, ensuring consistent moisture levels within the precious soil. To guarantee optimal delivery and prevent any potential shortcomings, a pump with ample power is meticulously chosen. This ensures that every drop reaches its designated area efficiently, fostering a thriving environment for the plants it nourishes.

Table 4.3 Sensor and Component Performance

Component	Parameter	Expected Value	Measured Value	Remarks
DHT22 Sensor	Temperature (°C)	25–35	26–34	Within acceptable range
	Humidity (%)	40–60	42–59	Accurate readings
Soil Moisture Sensor	Moisture Level (%)	30–80	32–79	Matches expected range
ESP32 Wi-Fi Module	Connectivity	Stable	Stable	No interruptions
Water Pump	Response Time (s)	<5	4.8	Quick response

The results demonstrated that all components performed within their expected ranges, with the sensors providing accurate and consistent data. The water pump activation was also reliable, ensuring timely irrigation.

4.3 Automated Watering Test

To evaluate the automated watering system, tests were conducted under varying soil moisture conditions. The pump activation threshold was set at 40%, and controlled experiments were performed to assess its reliability and efficiency. Table 4.2 presents the outcomes of these tests.

Table 4.4 Automated Watering System Results

Test No.	Initial Moisture Level (%)	Pump Activation (YES/NO)	Activation Time (s)	Final Moisture Level (%)
1	35	YES	4.5	50
2	42	NO	–	42
3	38	YES	4.2	47
4	45	NO	–	45

The system consistently activated the water pump when the soil moisture level dropped below the threshold. The response time was prompt, with the pump effectively increasing the moisture levels to optimal conditions for germination.

4.4 Real-Time Monitoring

The Blynk application served as the central interface for monitoring real-time data on temperature, humidity, and soil moisture levels. Notifications were configured to alert users about critical changes, such as low soil moisture or extreme temperature variations. Table 4.3 provides a detailed evaluation of the Blynk interface's performanc

4.5 Blynk Interface Evaluation

The integration of the Blynk platform significantly enhanced the system's usability, allowing for seamless monitoring and quick responses to environmental changes.

Table 4.5 Blynk Interface Evaluation

Parameter	Update Frequency (s)	Accuracy (%)	Notifications (YES/NO)	Remarks
Temperature (°C)	10	98	YES	Reliable and responsive
Humidity (%)	10	97	YES	Timely updates
Soil Moisture (%)	10	99	YES	Accurate and consistent

4.6 Summary of System Performance

The testing and evaluation phase validated the functionality and reliability of the SMARTSEED IoT-Enabled Germination Kit. Key findings include:

1. Accurate Monitoring: The DHT22 and soil moisture sensors provided precise data, ensuring accurate monitoring of environmental conditions.

2. Efficient Watering: The automated watering system demonstrated timely and effective performance, maintaining optimal moisture levels for seed germination.

3. User-Friendly Interface: The Blynk app offered a robust platform for real-time data visualization and notifications, enhancing the overall user experience.

These results confirm the SMARTSEED system's potential as an intelligent solution for improving plant growth management. The next chapter will present the conclusions and recommendations for future enhancements.

4.7 System Development

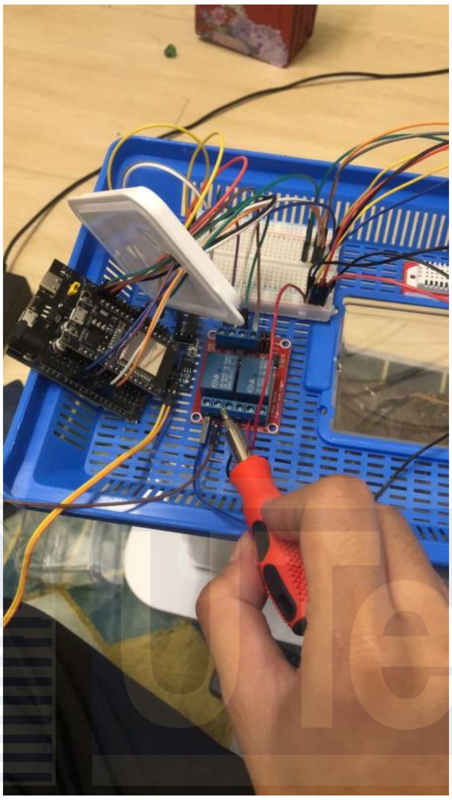


Figure 4.2 First Prototype Development

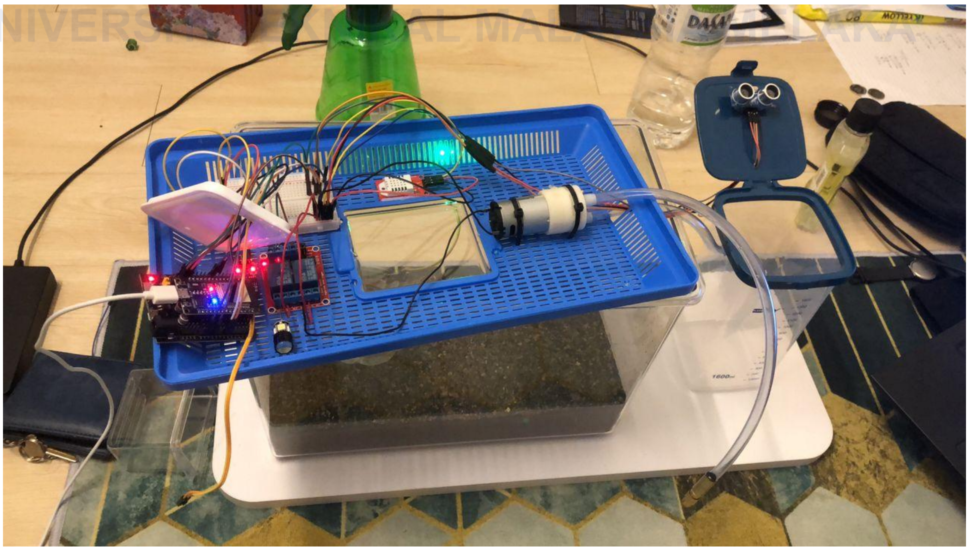


Figure 4.3 Second Prototype Development

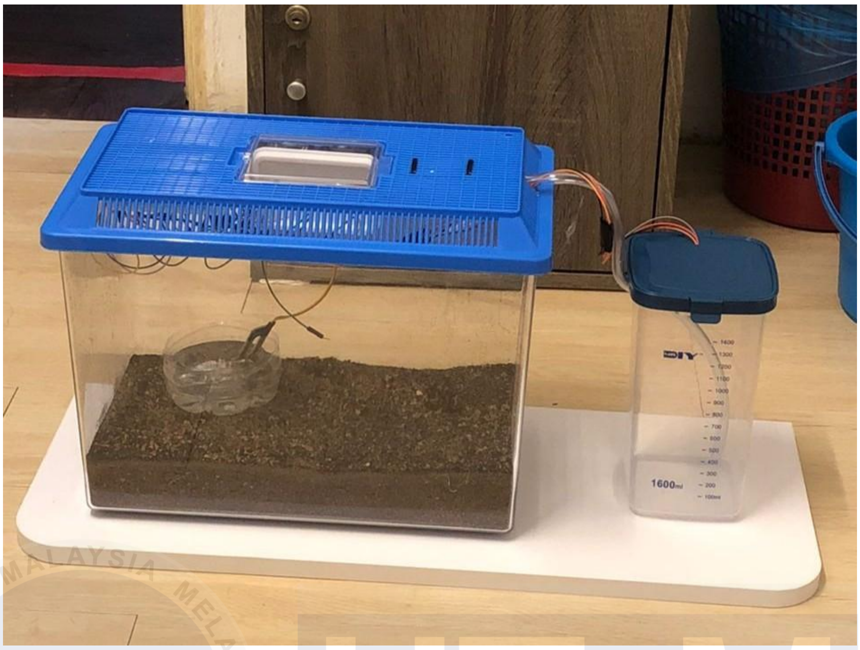


Figure 4.4 Final Project prototype

4.8 Coding Development

The ESP32 was programmed using the Arduino IDE, utilizing C++ for control logic implementation. Key programming components included:

- Sensor data collection and real-time analysis.
- Automated actuation for irrigation and UV light management.
- Data communication with the Blynk dashboard.

```
#define BLYNK_TEMPLATE_ID "TMPL6QU1keX2X"
#define BLYNK_TEMPLATE_NAME "Iot plant watering"
#define BLYNK_AUTH_TOKEN "1JfsziwAgDq3bAwRf66xXeCfaMvkqiIB"

#define BLYNK_PRINT Serial

#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
#include "DHT.h"
int pump = 13;
int soil = 35;
int uvlight = 12;
int ldr = 14;
const int trigPin = 19;
const int echoPin = 18;

char ssid[] = "YourNetworkName";
char pass[] = "YourPassword";

#define DHTPIN 2
#define DHTTYPE DHT22

int val = 0;
int light = 0;
int depth = 20;// ubah ikut kedalaman tank air dalam cm


DHT dht(DHTPIN, DHTTYPE);

void setup() {
Serial.begin(115200);
pinMode(pump,OUTPUT);
pinMode(uvlight,OUTPUT);
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);
}

void loop() {
Blynk.run();
long duration;
float distance;
float h = dht.readHumidity();
float t = dht.readTemperature();

if (isnan(h) || isnan(t)) {
    Serial.println("Failed to read from DHT sensor!");
  }
Serial.print("SUHU : ");
Serial.println(t);
Blynk.virtualWrite(V0,t);
Blynk.virtualWrite(V1, h);

val = analogRead(soil);
int moist = map(val , 0 , 4096 , 100 , 0);
Blynk.virtualWrite(V2,moist);
Serial.print("Soil Moist : ");
Serial.print(moist);
Serial.println("%");

if(moist > 49 && moist <= 69){
  Serial.println("Soil Moisture Ideal");
  digitalWrite(pump,LOW);
  delay(500);
   }

 if(moist > 70){
 Serial.println("Soil Moisture Low");
 digitalWrite(pump,HIGH);
 delay(500);
  }
light = analogRead(ldr);
Serial.print("Ambient Light : ");
Serial.println(light);
Blynk.virtualWrite(V3, light);
if(light >= 300){
  digitalWrite(uvlight,LOW);
  }
else{
  digitalWrite(uvlight,HIGH);
  }

  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distance = (duration * 0.0343) / 2;
  float percent = (depth-distance)/depth*100;
  Blynk.virtualWrite(V4,percent);
 delay(1000);
}
```

Figure 4.5 Final Prototype Coding

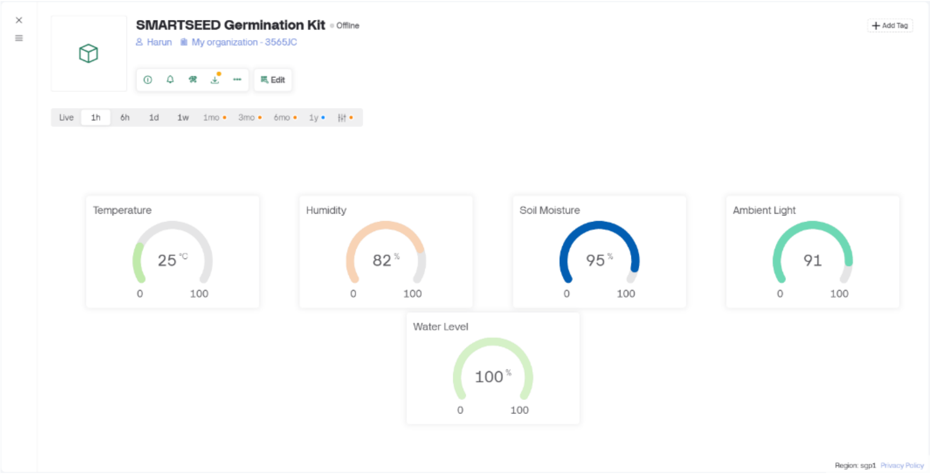


Figure 4.6 Finished Blynk system dashboard setup

4.9 Cultivation Growth

In the past, achieving successful germination was often a matter of experience and intuition, leading to inconsistent yields. Factors like moisture, temperature, and light are crucial, but traditional methods relied on educated guesses. This can result in germination rates hovering around 60%, with many seeds failing to sprout due to less-than-ideal conditions. However, the implementation of IoT sensors and automation can transform this process. By precisely monitoring these critical factors, growers can gain real-time insights and make adjustments to optimize the germination environment. With IoT, what was once a waiting game with uncertain results becomes a data-driven approach. By creating ideal conditions for each seed type, growers can expect a significant improvement in germination rates. Studies suggest that IoT-powered systems can potentially increase yields of healthy seedlings by 15- 20%, leading to a higher number of strong viable plants for the next stage of growth [22].

Experiments were conducted on Lactuca Sativa (lettuce) seeds in controlled and uncontrolled environments for eight days:

1. **Controlled Environment**: Optimal temperature, humidity, and UV light exposure.

2. **Uncontrolled Environment**: No active monitoring or adjustments.

Table 4.6 Daily Growth Measurement

Environment	Germination Rate	Average Grow Height (cm)							
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Controlled	95%	1.2	2.5	4.0	5.6	7.3	9.2	11.0	12.5
Uncontrolled	70%	0.8	1.5	2.5	3.6	5.0	6.4	7.5	8.2

4.10 User Feedback and Review

In order to having feedback about the SMARTSEED system, a Google Form was filled by the potential users such as the lovers of agriculture, students and professionals of the agriculture field. The form included questions that assessed the usability of the system, how easy it was to use and possible effects on the growth of plant. Participants were also asked to give recommendations for addition improvements.

Key Questions in the Google Form:

1. Are you interested in growing plants at home with the help of a smart system that automatically adjusts temperature, humidity, and moisture?

2. How important is it for you to monitor your plants' growth and health remotely using a smartphone app?

3. Would you find it helpful if a system could automatically water your plants only when the soil is dry?

4. How comfortable are you using technology like sensors and mobile apps for everyday gardening?

5. Would you prefer a system that can send alerts when conditions like soil moisture or temperature need adjustment?

6. Would you be willing to invest in a germination kit with automated features like UV light and watering systems?

4.11 Summary of Feedback:

Are you interested in growing plants at home with the help of a smart system that automatically adjusts temperature, humidity, and moisture?

32 responses

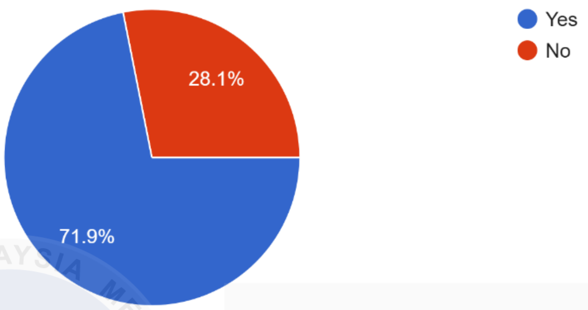


Figure 4.7: Are You Interested In Growing Plants At Home With The Help Of A Smart System That Automatically Adjusts Temperature, Humidity, And Moisture?

How important is it for you to monitor your plants' growth and health remotely using a smartphone app?

32 responses

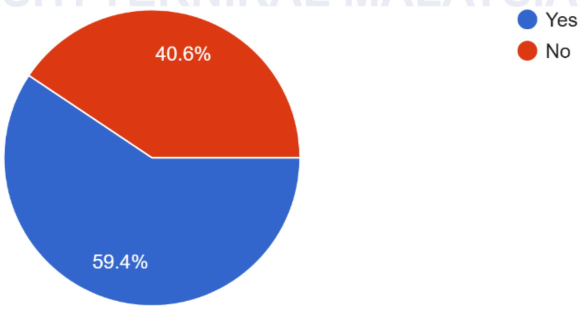


Figure 4.8: How Important Is It For You To Monitor Your Plants' Growth And Health Remotely Using A Smartphone App?

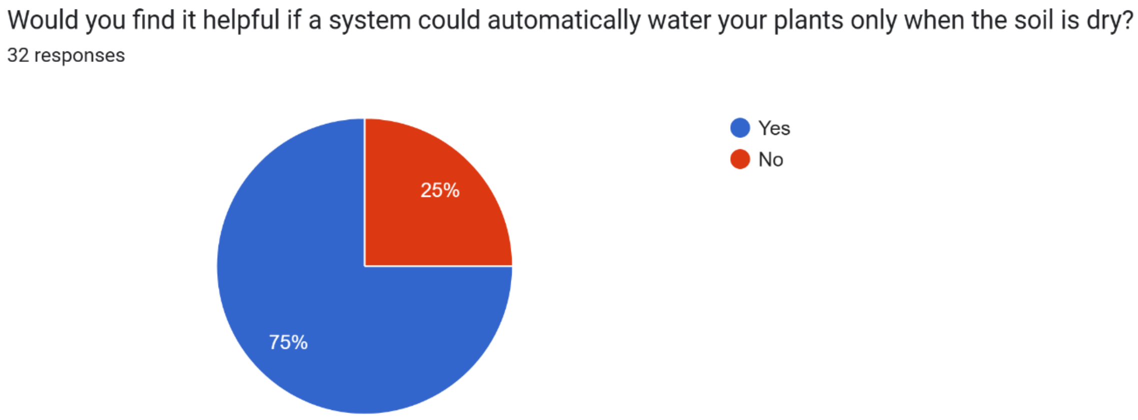


Figure 4.9: Would You Find It Helpful If A System Could Automatically Water Your Plants Only When The Soil Is Dry?

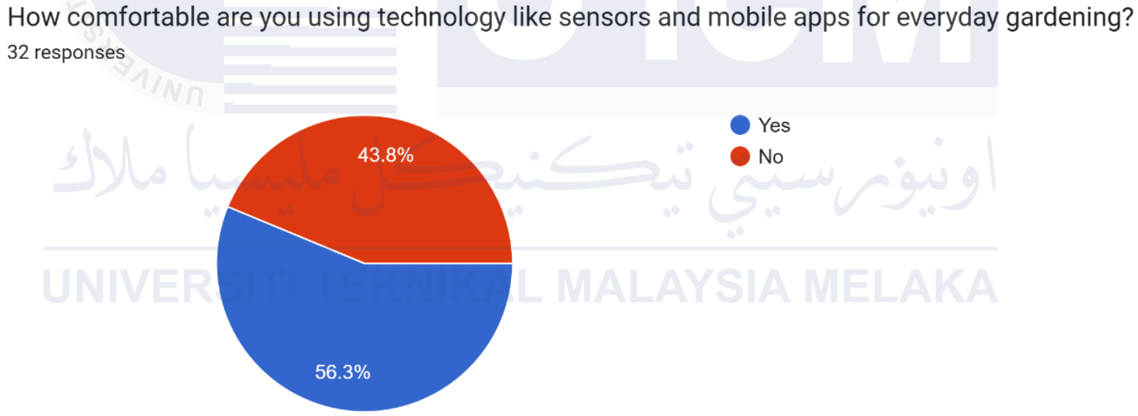


Figure 4.10: How Comfortable Are You Using Technology Like Sensors And Mobile Apps For Everyday Gardening?

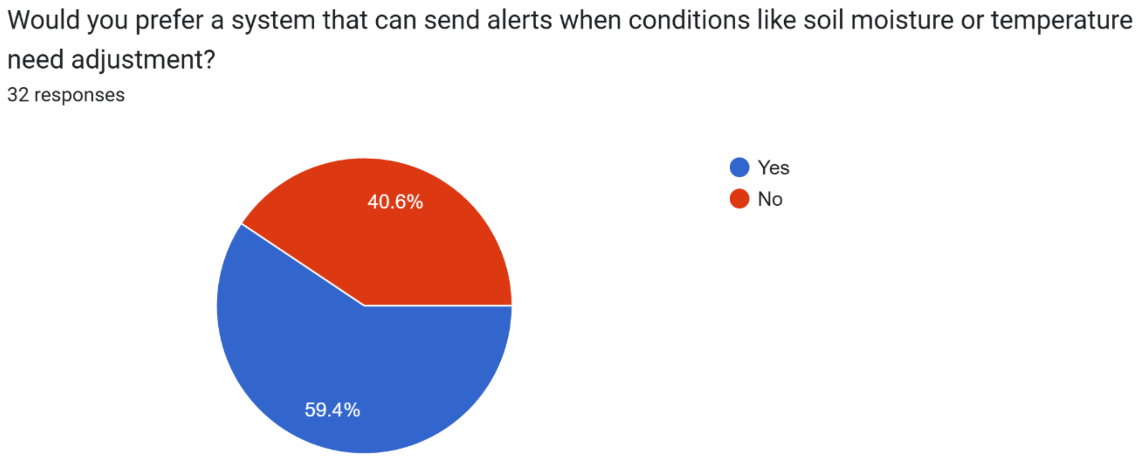


Figure 4.11: Would You Prefer A System That Can Send Alerts When Conditions Like Soil Moisture Or Temperature Need Adjustment?

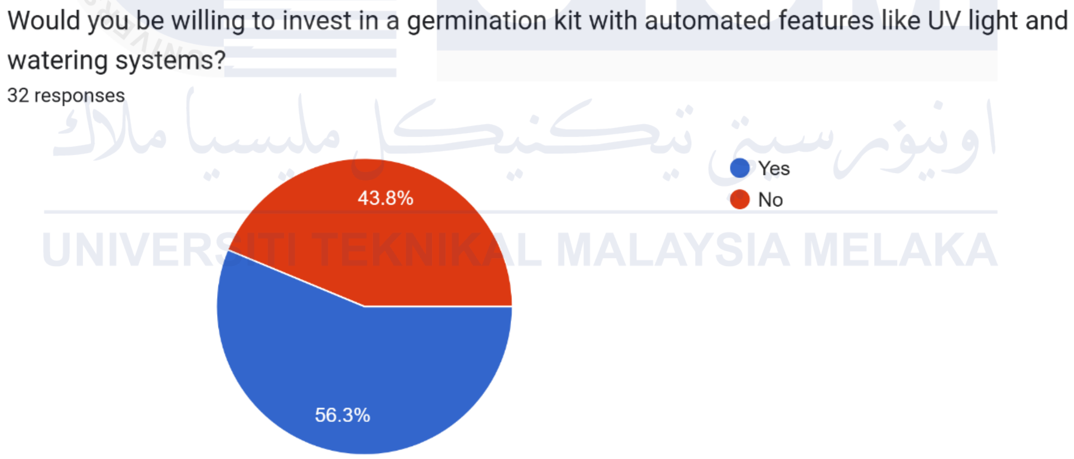


Figure 4.12: Would You Be Willing To Invest In A Germination Kit With Automated Features Like UV Light And Watering Systems?

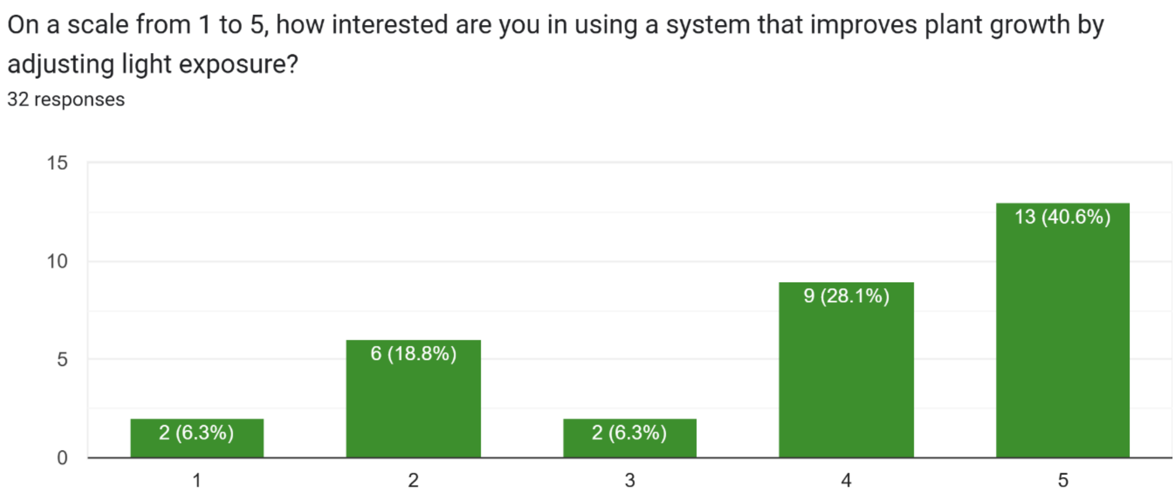


Figure 4.13: Would You Prefer A System That Can Send Alerts When Conditions Like Soil Moisture Or Temperature Need Adjustment?

This feedback demonstrates the potential for SMARTSEED to flourish in the market. User input will be vital in guiding further developments to meet the evolving needs of the agricultural sector.

4.12 Discussion

The traditional germination that depended mostly on the overall intuition has always been characterized by rather high variability. However, through an exclusive application of the current example that is the Internet of Things (IoT) empowered system, this aspect of plant growth has been enhanced greatly. The system has now connected a network of sensors, which provides an opportunity to monitor the necessary parameters of the microclimate, including humidity, temperature and light intensity.

This real time data has propelled a precise control in germination and not a trial-and-error method again as was the case before. The opportunity has been opened to let growers manage the data and manipulating the environment to suit different seeds. By so doing, with automation in place, the system has well provided for the creation of the right climates for germination and has done so with measures of precision

These have yield positive results with the germinating capacity of the seeds up to 15-20% compared to its previous efficiency, hence recorded improved crop yield due to better seedling productivity. It not only increases the quality of seedlings but also helps make better profits in the agricultural business. Although main risks including the initial investment costs and data security aspects were always considered during the evolution of the IoT system, the potentials of the technology have been revolutionary.

As the system has been running, it is pretty clear that the germination's future is in IoT powering a more stable and effective agriculture. Therefore, the smart germination system for automation of UV-light and watering of Lactuca Sativa and the overall control objectives has been developed and implemented as planned to enhance comprehensive healthy germination of the seeds.

In conclusion, we are able to say that the system manage to do the intended purpose of the system in regards of smart germination system with automated UV-Light and watering system for Lactuca Sativa.

4.13 Planning Gantt Chart for PSM 2

Planning Gantt Chart for PSM 2 as shown in Figure 3.14 is my plan to continue and get the result for my Research. This is to show my activities and planning during the duration given.

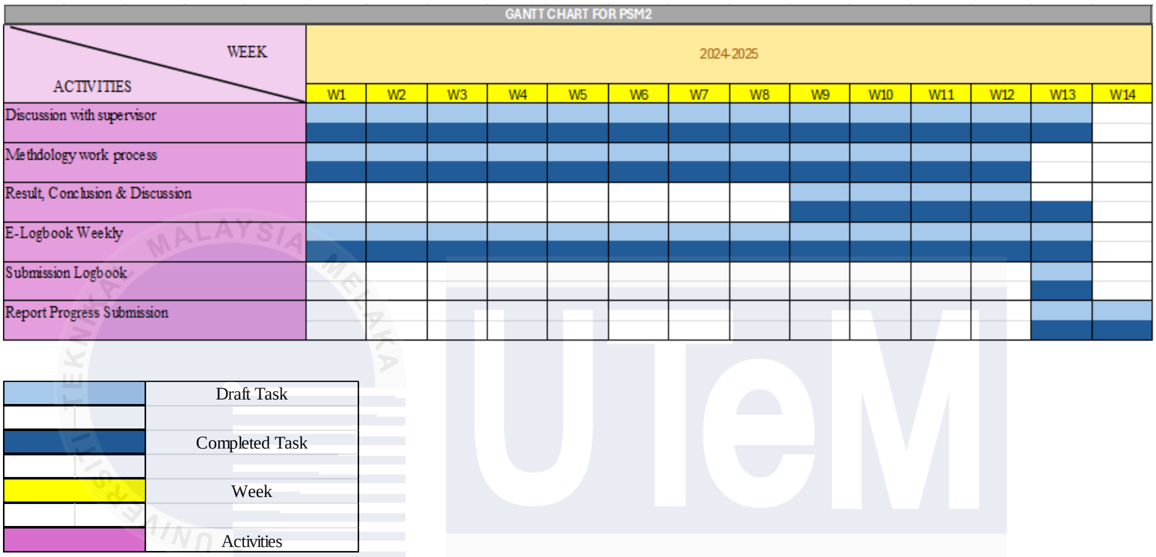


Figure 4.14 Planning Gantt Chart for PSM 2

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This project represents a significant leap forward in applying IoT technologies to address real-world challenges innovatively. The SMARTSEED: IoT-Enabled Germination Kit serves as a tangible example of this approach, demonstrating how IoT can be harnessed to drive efficiency and productivity in agricultural practices. The SMARTSEED Kit successfully fulfills its primary objective of optimizing plant germination by monitoring and controlling key environmental parameters. By automating irrigation based on real-time data, it has the potential to revolutionize traditional agricultural practices, enhancing precision while reducing the need for constant human intervention. This system underscores the transformative potential of IoT in solving practical problems and improving various aspects of everyday agricultural operations.

5.2 Potential Commercialization

The potential for commercializing the SMARTSEED: IoT-Enabled Germination Kit is substantial due to its innovative design and practical utility. Equipped with remote monitoring capabilities and automated irrigation, it stands out as a valuable tool for farmers, agricultural researchers, and urban gardeners alike. Its scalability and adaptability to both small-scale and large-scale applications ensure broad market appeal. The modular design not only enhances usability but also positions it as an ideal solution for diverse agricultural settings. As a product, the SMARTSEED Kit has the potential to make a significant impact on the agricultural sector by promoting efficiency and sustainable practices. The integration of its features into modern agricultural techniques positions it as a cutting-edge solution for optimizing germination processes and overall crop yield.

5.3 Future Works

There is considerable scope for enhancing the SMARTSEED: IoT-Enabled Germination Kit to further improve its functionality and readiness for commercial deployment. Future developments could include features such as monitoring soil pH, nutrient levels, and weather patterns to offer a more comprehensive approach to plant care. The integration of artificial intelligence and machine learning algorithms could enable predictive analytics and adaptive irrigation schedules, optimizing its performance across different crops and climatic conditions. Incorporating renewable energy solutions, such as solar panels, would improve sustainability by reducing reliance on conventional power sources. Furthermore, conducting extensive field trials in various agricultural settings will help refine the system, ensuring its reliability and robustness under diverse conditions.

In conclusion, the SMARTSEED: IoT-Enabled Germination Kit exemplifies the power of IoT technologies in addressing modern agricultural challenges. Through continued innovation, rigorous testing, and iterative development, this system has the potential to evolve into a market-ready solution that redefines practices in agriculture. Its adoption will not only optimize existing processes but also set the stage for sustainable, technology-driven advancements in the agricultural sector.

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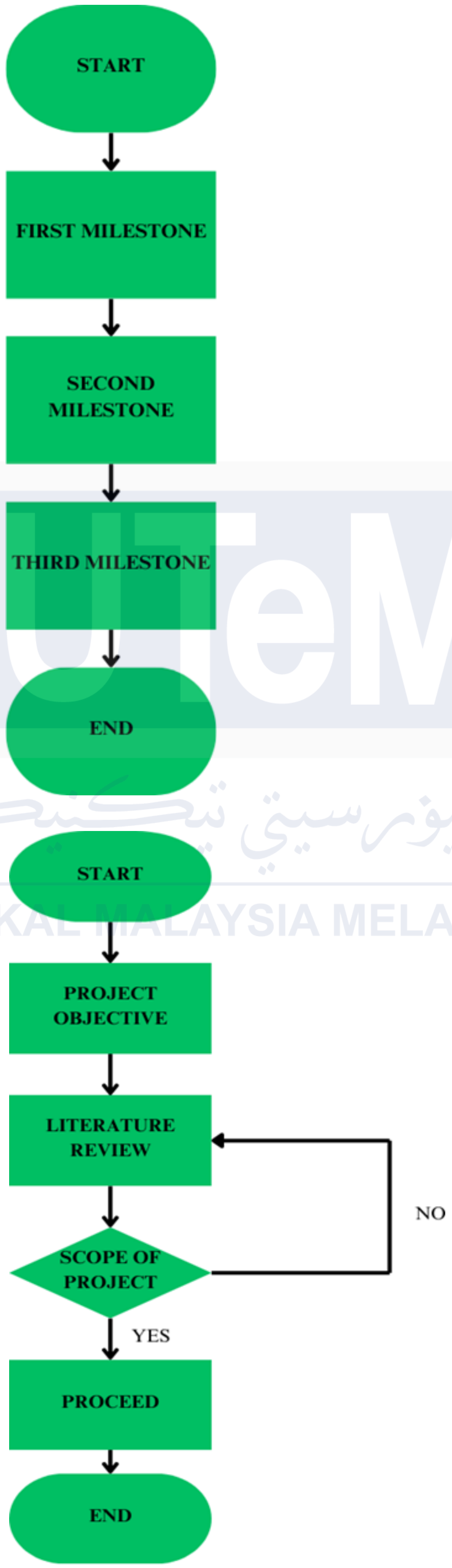
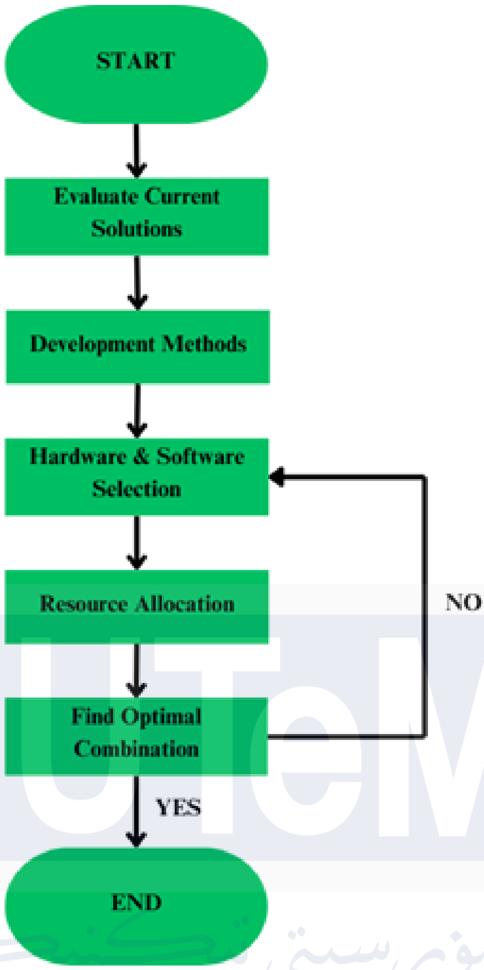
APPENDICES

Appendix A Full Programming Written in C++ Language

```
#define BLYNK_TEMPLATE_ID "TMPL6QU1keX2X"
#define BLYNK_TEMPLATE_NAME "Iot plant watering"
#define BLYNK_AUTH_TOKEN "1JfsziwAgDq3bAwRf66xXeCfaMvkqiIB"

#define BLYNK_PRINT Serial

#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
#include "DHT.h"
int pump = 13;
int soil = 35;
int uvlight = 12;
int ldr = 14;
const int trigPin = 19;
const int echoPin = 18;

char ssid[] = "YourNetworkName";
char pass[] = "YourPassword";

#define DHTPIN 2
#define DHTTYPE DHT22

int val = 0;
int light = 0;
int depth = 20;// ubah ikut kedalaman tank air dalam cm


DHT dht(DHTPIN, DHTTYPE);

void setup() {
Serial.begin(115200);
pinMode(pump,OUTPUT);
pinMode(uvlight,OUTPUT);
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);
}

void loop() {
Blynk.run();
long duration;
float distance;
float h = dht.readHumidity();
float t = dht.readTemperature();

if (isnan(h) || isnan(t)) {
    Serial.println("Failed to read from DHT sensor!");
  }
Serial.print("SUHU : ");
Serial.println(t);
Blynk.virtualWrite(V0,t);
Blynk.virtualWrite(V1, h);

val = analogRead(soil);
int moist = map(val , 0 , 4096 , 100 , 0);
Blynk.virtualWrite(V2,moist);
Serial.print("Soil Moist : ");
Serial.print(moist);
Serial.println("%");

if(moist > 49 && moist <= 69){
  Serial.println("Soil Moisture Ideal");
  digitalWrite(pump,LOW);
  delay(500);
   }

 if(moist > 70){
 Serial.println("Soil Moisture Low");
 digitalWrite(pump,HIGH);
 delay(500);
  }
light = analogRead(ldr);
Serial.print("Ambient Light : ");
Serial.println(light);
Blynk.virtualWrite(V3, light);
if(light >= 300){
  digitalWrite(uvlight,LOW);
  }
else{
  digitalWrite(uvlight,HIGH);
  }

  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distance = (duration * 0.0343) / 2;
  float percent = (depth-distance)/depth*100;
  Blynk.virtualWrite(V4,percent);
 delay(1000);
}
```

Appendix B PSM Research Flowchart




START
Evaluate Current Solutions
Development Methods
Hardware & Software Selection
Resource Allocation
Find Optimal Combination
NO
YES
END

Appendix C PSM Gantt Chart