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SMART PLANT MONITORING UTILIZING IOT AND ARDUINO: SOFTWARE DEVELOPMENT

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A project report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology with Honours



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this project report entitled "Smart Plant Monitoring System Utilizing IoT and Arduino: Software Development" 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.

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APPROVAL

I hereby declare that I have checked this project report and, in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology with Honours.

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DEDICATION

I acknowledge my sincere dedication, honours, and gratitude to both of my parents for them love, encouragement, supports, and sacrifices throughout whole of my life. Without them sacrifices and encouragement, I cannot possibly reach this stage. Special gratitude also dedicated to my siblings which always support and advise me in whatever I do in my life and who have been my source of inspiration and continually provide their moral, spiritual, emotional, and financial support. Special thanks to all of lecturers especially my supervisor Dr. Azhan Bin Ab Rahman and my academic advisor who had taught and guided me throughout my studies and during this Bachelor Final Project 1 progress. I would like to thank all my friends who always been with me throughout this challenging semester and help me during movement control order (MCO). I hope all their supports and encourage will help me make this project a success.



ABSTRACT

This paper is about Internet of Things (IoT) and Arduino -based smart plant monitoring systems that represent the idea of controlling crop problems in an integrated system. The project aims to design a crop monitoring system to maintain crop health to maximize crop growth. Combining smart systems with crop monitoring makes farming easier. Growers face problems in maintaining crop health outcomes. Therefore, a system was built to maintain the health of the crop which is the first Arduino board system used to deal with input and output signals which contains the use of several sensors according to the characteristics of the crop. Further, the second system is a server that sends data from the Arduino to the Firebase and the third system is the app inventor of the Android Studio to deliver information to the user about the health condition of the plant can only be seen through the app on the user's smartphone. The provided implementation works in conjunction with cloud -based servers and mobile -based devices (ideally Android / iOS devices) that help users to control and view crop status monitored by hardware devices. Finally, the project was successfully implemented and achieved the objective of developing a prototype for an IoT -based crop health monitoring system and with the advancement of innovative techniques, could help produce more results with less manpower while maintaining crop health to maximize growth.

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ABSTRAK

Kertas kerja ini adalah mengenai Internet of Things (IoT) dan sistem pemantauan tumbuhan pintar berasaskan Arduino yang mewakili idea mengawal masalah tanaman dalam sistem bersepadu. Projek ini bertujuan untuk mereka bentuk sistem pemantauan tanaman untuk mengekalkan kesihatan tanaman untuk memaksimumkan pertumbuhan tanaman. Menggabungkan sistem pintar dengan pemantauan tanaman menjadikan pertanian lebih mudah. Penanam menghadapi masalah dalam mengekalkan hasil kesihatan tanaman. Oleh itu, satu sistem dibina untuk mengekalkan kesihatan tanaman iaitu sistem papan Arduino yang pertama digunakan untuk menangani isyarat input dan output yang mengandungi penggunaan beberapa sensor mengikut ciri tanaman. Selanjutnya, sistem kedua ialah pelayan yang menghantar data daripada Arduino ke Firebase dan sistem ketiga ialah pencipta aplikasi Android Studio untuk menyampaikan maklumat kepada pengguna tentang keadaan kesihatan loji hanya boleh dilihat melalui aplikasi pada telefon pintar pengguna. Pelaksanaan yang disediakan berfungsi bersama-sama dengan pelayan berasaskan awan dan peranti berasaskan mudah alih (idealnya peranti Android / iOS) yang membantu pengguna mengawal dan melihat status tanaman yang dipantau oleh peranti perkakasan. Akhirnya, projek itu berjaya dilaksanakan dan mencapai objektif untuk membangunkan prototaip untuk sistem pemantauan kesihatan tanaman berasaskan IoT dan dengan kemajuan teknik inovatif, dapat membantu menghasilkan lebih banyak hasil dengan kurang tenaga kerja sambil mengekalkan kesihatan tanaman untuk memaksimumkan pertumbuhan.

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LIST OF SYMBOLS

Time Т _ С Speed of sound _ Voltage V _ А Current _ W Power _ Temperature °C _ Frequency Hz _ Carbon Dioxide CO_2 Oxygen O_2 Wavelength (nanometers) nm Voltage angle δ **UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

LIST OF ABBREVIATIONS

IoT	- I1	nternet of Things
LDR	- L	ight Dependent Resistors
MIT	- N	Aassachusetts Institute of Technology
SoC	- S	ystem-On-a-Chip
kB	- k	iloBytes
MB	- N	AegaBytes
IDE	- I1	ntegrated Development Environment
XML	AT HAL	Extensible Markup Language
RH	- R	Relative Humidity
ID	E - I	dentifier
MIPI	-3477	Aobile Industry Processor Interface
DC	املاك	اونيوبرسيني تيڪنيڪherent
LCD		iquid Crystal Display
UI	- L	Jser Interface
V	- V	Voltage

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CHAPTER 1

INTRODUCTION

This section provides an overview of the project's history as well as the project's main goals and priorities. This section describes the scope of the analysis that will be performed throughout the project. The problem statement explains why the discovery was made and how it will be solved.

1.1 Background LAYS/A

Because of the world's rapidly growing population, agriculture is becoming increasingly important. Rather than buying flowers and vegetables, more people are opting for a personal garden where they can grow their own. Plants are required for the proper functioning of the ecological cycle. Crop growers are increasingly using modern farming techniques to produce their crops. Improving the tools and technologies that enable growers to increase their output, such as modern irrigation methods, crop management, and crop management using mobile technology, is the most difficult aspect of increasing crop yields.

The Internet of Things (IoT) is a concept that enables objects to communicate with one another over the internet. It refers to the interconnections between everyday objects and the Internet that allow people to meet more frequently and efficiently. The Internet of Things (IoT) is a scenario in which all sensors and devices are connected to wireless communication devices so that they can communicate with one another, send, and receive data, and control parameters without the need for human intervention. Cloud computing and the Internet of Things are linked in terms of data storage. An automatic method for monitoring and irrigation system is proposed to continuously monitor the health and growth of the plant in a regulated environment. The system's main goal is to learn how plants behave by observing and analyzing the factors that influence their growth. This allows the user to monitor and control his or her health from a distance. With the introduction of the Internet of Things, plant health monitoring has entered a new era (IoT). Sensors are linked to Arduino, which logically connects all the circuits. The system uses IoT technology to provide real-time monitoring of key environmental parameters that affect plant growth, such as soil moisture, light intensity, temperature, and water acidity.

Irrigation is a critical component of agricultural production. Soil properties such as moisture determine the amount of water required by the soil. An irrigation system that is well-designed can have a significant impact on the entire growth process. Hand-operated irrigation systems account for most irrigation systems. In place of this technique, an automatic irrigation system can be used to provide enough water for the plants. The sensor - based automatic watering system provides a promising solution to the user as it can reduce manual intervention. In this system, soil moisture sensors are used to detect crop soil moisture[1]. Based on the soil moisture level, the system will send information on the soil moisture level if there is insufficient water, or the soil condition is too dry to the user.

Plant growth productivity is influenced by factors such as water acidity, soil humidity, and light intensity. As a result, sensors like pH level sensors, ultrasonic sensors, and soil moisture sensors are used to detect any changes that may affect the plant. The user can remotely monitor the plant using their smartphone after analyzing and storing the data in the cloud.



1.2 Problem Statement

Plant health is a prerequisite for long-term land sustainability. It can expose them to a variety of issues that can endanger their health, leading to serious consequences such as decreased crop yield and quality, as well as plant death. Plant health issues can be caused by a variety of factors, including moisture, lighting, and acidity. It can affect the flowers, leaves, stems, branches, growing tips, and roots of plants in a variety of ways. Dry soil, for example, can cause root damage and death. Furthermore, too much direct sunlight can cause the leaves to dry out. If one of these parameters is outside of the plant's ideal range, it will affect its growth and health. As a result, in order to produce healthy crops, many farmers and growers must pay more attention to the plants [2].

In recent years, there has been a surge in interest in indoor plants which can be utilized to produce food or simply for decoration and health benefits. The rising city congestion and less available area for outside plants have caused the use of indoor plants to soar to maintain a connection with nature[3]. Furthermore, flowering plants, for example, require at least six hours of direct sunlight every day, although direct sunshine can affect the plants. Especially when the sun is up strongly. It is best to put the plant somewhere that gets plenty of morning and evening sun but is partially shaded from direct sunlight. For good growth, flowering or vegetable crops require little soil moisture throughout their root zone[2]. Watering too often or too lightly can cause a shallow root system. Majority of people spend their time indoors, either at home or working in an office environment. As such, it is important to ensure the air quality is clean. An average home has dangerous toxins such as carbon monoxide, formaldehyde; found in synthetic fabrics, benzene; found in tobacco smoke and paint, and animonia; found in cleaners and waxes. Indoor plants are most likely filters and purifies the air inside the house as it absorbs up to 90% of indoor air pollutants.

One of the common problems growing plants indoor is difficulties on watering the plants. The right amount of water to irrigate the plant is crucial as overwatering could lead to some other problems that can reduce the crop yields. Many people are lack of knowledge regarding this matter as different plants require different amount of water. In addition, monitoring the soil moisture content also important to avoid from overwatering. Hence, developing irrigation system utilizing soil moisture sensor and motor pump to irrigate the plants helps to lighten the burden of the user. The goal of this system is to detect the water content of soil moisture, which is dependent on the crop's demands.

Moreover, for people who lives in high-rise building such as apartment or condominium are facing difficulties to grow plants as the space might not be able to receive a proper sunlight. In addition, every plant has different light requirements and exposing them to direct sunlight for a long time can be hazardous to this plant especially when the sun is scorching hot.

This project aimed to create a monitoring system that can automatically irrigate enough water to the plant without requiring any manual labor, as well as a monitoring system that can solve the lighting issue. Furthermore, using a smartphone, the user can remotely monitor the plant's health.

1.3 Project Objective

Crop health can deteriorate day by day due to lack of maintenance. An important aspect of this project is to create a system that can reduce the workload of manual intervention, as well as solve most agricultural problems by reducing crop mortality from environmental parameters that can affect crops. The main aim of this project is to propose a system that helps growers monitor the health status of crops. Specifically, the objectives are as follows:

- a) To design and develop an internet-of-things-based (IoT) system for monitoring plant health.
- b) To test the proposed system's functionality based on soil moisture, humidity, water level, and pH level.
- c) To verify the effectiveness of the proposed system with a real-life case study will be used.

1.4 Scope of Project

The scopes of this project can be described as follows:

- a) The system is built with MIT applications that can show crop parameters including soil moisture, water pH, and lighting intensity for plant health monitoring and by giving safe access to the database directly from grower, Firebase can store and sync data amongst your users in real time and collaborative apps.
- b) The proposed system is tested with real crops and a monitoring system made up of Arduino board signals that use sensors to measure crop parameters, as well as data collection using cloud-based servers from Firebase and mobile devices.
- c) Validate effectiveness of the proposed system is demonstrated by the display results on the grower's phone application.

1.5 Thesis Outline

There are a total of five chapters in this thesis, including introduction, literature review, methodology, outcome and discussion, and conclusion and recommendation. The outline of the project and the progress of the work are discussed and written in detail corresponding to each chapter.

The main objective of Chapter One is to introduce the project to the target audience by identifying the reasons and the kick-starter for starting this project. This chapter is detailed explains the background of the project with its related real-life problems.

Chapter Two reviewed the past research journal and the related case study. This chapter mainly discusses and analyses the literature on automated monitoring systems and their equivalents. Information from different research papers related to the system before this project is critically analyzed and summarized. Summary information is integrated into an automated design.

Chapter three focuses on the methodology of the project and the process taken to complete the project. The application of the software program and hardware development are discussed in this chapter. This chapter also highlights the equipment involved in this project, together with the specification for each part of the elements used.

Chapter four highlights information developments for all variables involved in this project. The detailed methods used for data capture are outlined in this chapter, together with the proper figures, tables, and charts. To improve the project's outcomes, an analysis was performed and reviewed.

1.6 Project Significant

The main target audience of this project is growers. The project is aimed at users, who want to grow their own plants, therefore the system helps users to monitor crops with the help of a software system developed. This system is suitable for people who do not have the time or have no knowledge of how to monitor crops in detail. The proposed system will constantly monitor the health condition of the plants on the app via a smartphone. In addition, the system is designed to maximize plant growth in a good way. With one click on a smartphone, users will be able to get all the information about the health of their crops, wherever they are.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A literature review is a collection of academic references, such as journal articles and theses, that are relevant to a specific subject or study issue. It's sometimes included in a thesis, essay, or research article to help readers see how the research fits into the bigger picture. This chapter discusses previous research that applies to this project based on a journal, thesis, or other types of published information in a circle within the scope and context of the project.

During the literature review, the researcher will learn about other people's methods to use them as guides for this project. It will allow the researcher to learn more about the project and come up with new methods to develop or create.

2.2 Literature Survey

کنیکا ملیست

The design of the project is to android smartphones may connect to the Indoor Plant Monitoring System. The growers interact with the android application, which updates the current state of the plants' surroundings via sensors placed around them. The sensors collect ambient temperature, humidity, and soil moisture and send them to the cloud, where they are presented on the user's Android device's UI. The user interface also allows you to add several plants and water them with a single click of the app's button. By clicking on a photo of the plant's leaf, the viewer may see if it is infected with the illness[4].

Tomen is an IoT-based plant monitoring and smart gardening system controlled by a Raspberry Pi. This aids in ensuring that plants grow by recording and monitoring environmental variables. The system keeps track of all garden factors like as humidity, temperature, soil moisture, light intensity, and pH, and all information is stored in a database (Storage-SD card in Raspberry Pi). Tomen continually monitors the garden's conditions and warns the user to any changes that necessitate rapid action[5].

The automated technology will eliminate the requirement for human labor, lowering the risk of mistake. Technology for plant watering and monitoring will send input to users via smart phones or laptops. Using IoT (Internet of Things) and cloud computing, we can water and monitor the plant in this setup. It is nearly hard for a farmer to monitor the efficiency of a system on a big scale. However, by using this technology, a farmer may simply monitor the system using their smart devices [6].

Hence, from literature survey based on greenhouse design the automation of fertilizer, intelligent irrigation, and smart greenhouse are just a few of the precision agricultural studies that have been conducted. The study makes use of technology, including the use of a wireless sensor network (WSN) In the sphere of information technology, WSN is a solution for making precision agriculture a reality[7].

Agriculture uses the most water. Irrigation methods that are used in the past are useless and waste a lot of time and effort. These issues will be considerably alleviated with the use of smart watering systems. The suggested system is made up of three primary components: a wireless sensor network (WSN), a control unit, and cloud services. The data acquired by the system is kept in the cloud to produce instance visualizations of live data and issue warnings. This enables growers to keep track of their crops' progress and make the necessary decisions[8].

Other part, with the usage of, a smart plant monitoring system takes use of the idea of ambient intelligence. Gadgeteer on the Internet. Changes in moisture, temperature, and light conditions in and around the plant are detected by the device. An android/web application would be used to handle the data retrieved by the device. This information will be examined, and the app will offer advice on the best gardening solutions for that plant. This is an Internet of Things-based project that will be capable of assessing numerous soil parameters such as moisture, temperature, and light[9].

2.3 Research, Ideology and Concept from the Previous Project

2.3.1 Wireless Sensor Network

In everywhere now, there seem to be a lot of agriculture systems that use different ways to implement their systems. Approaching the agriculture era, a smart plant monitoring system appears to be planned to change some of the problems in the future. One of them is the Wireless Sensor Network (WSN). Wireless Sensor Network (WSN) is a cutting-edge technology that is gaining popularity in the modern world due to its low-power wireless communication, low-cost performance, low-power detector nodes, and self-healing capability. This refined expertise drives detector application materialization and rapid development in the integration of digital electronic equipment that plays critical roles in such areas as cultivation, environmental fortification, and intelligent machines[10].

WSN is made up of three major components: sensor nodes, gateways, and software. Sensor nodes collect data on environmental conditions. The data is wirelessly delivered through the gateway to be collected, processed, and displayed by the software. The fundamental principle of using internet technology and WSN will serve as the foundation for the implementation of the Internet of Things (IoT).

2.3.2 Smart Garden Monitoring using IoT

The smart gardens paper proposes using a Node MCU as the system's brain to interface multiple types of sensors such as moisture sensors, humidity sensors, temperature

sensors, and ultrasonic sensors, based on an article written by T. Thamarai Manalan et al [11] on the 8th of April, 2018. The data from the sensors is sent to the Node MCU's integrated Wi-Fi technology. It is powered by a single Espressif Systems ESP8266 microcontroller. Espressif Systems' ESP8266 Wi-Fi SoC, which is a single microcontroller board with 128 kB of memory and 4 MB of storage, powers it.

Firebase is used as the database because the values of real-time sensors change every second. It's a Google-owned app development platform for smartphones and the web. Node MCU downloads the sensors into Firebase in real time. Studio software, which is commonly used to develop Android apps, will be used to establish the connection between the app and Firebase. It's controllable via mobile apps, so the user can keep track of the parameters from anywhere.

JetBrains' Android Studio is an open-source IDE for developing Android apps. It has a few features that allow users to create more user-friendly Android apps. The software for the smart garden the design code is written in XML, and the code is written in Java.. Firebase connectivity is completed during the implementation phase. The Smart Garden system can be tracked and managed remotely or locally using mobile apps. The user is notified When the sensor's values exceed the limit or threshold, action can be taken from a distance.

The project is said to have a low initial installation cost, making it easy to implement anywhere.



Figure 2.1 IoT-based smart garden monitoring system block diagram

2.3.3 Sensor used in Precision Agriculture

Based on journal written by Goel, Kunal, Bindal, Amit Kumar [12] on year 2018, its main goal is to prevent crop losses caused by diseases like "eyespot," "Pseudomonas Syringae," "Phomalingam," "Leptosphaeria Maculans," "Alternaria-Dligst," and "Phytophthora." The progression of the illness is influenced by environmental factors such as ratio and temperature. As a result, sensors are strategically placed throughout the cultivate field to track the microclimate. The weather or temperature in a specific area can be closely monitored, especially if it differs from the weather or temperature in the neighborhoods surrounding it.

The purpose of this paper is to discuss the use of sensors in the irrigation field The sensors are put to the test with a smart watering system that includes valves to help with irrigation. In recent years, water resources have become contaminated. Rivers, canals, ponds, lakes, wells, and other water resources are just a few examples. Because of rising population,

climate change, and rapid urbanization, water has become a scarce resource. The "soil moisture sensor" detects moisture in the soil and makes efficient use of water.

The system integrates all sensors and components for real-time statistics. Communication is done with wireless sensor networks. Mobile computing is an efficient technology to support the internet of things for developing real-life systems[13].

2.3.4 An IoT-based Plant Health Monitoring System with a Novel Approach

In a project put together by Srinidhi Siddagangaiah [14] The data is saved in Ubidots IoT cloud platform and is collected using sensors like temperature and humidity sensors installed at the plant. The system's main goal is to keep track of the plants and make sure they get enough water and sunlight. Teemu Ahonen, et al [15] used three commercial sensors to conduct a study to determine various environmental critical factors in greenhouse control.



Figure 2.2 IoT-based lant health monitoring system block diagram

The Internet of Things (IoT) system for monitoring plant health, as seen in Figure 2.3, the DHT-11 humidity and temperature monitoring sensor, which has a humidity range of 20% to 90% and a precision of 5.0 percent RH, is among the hardware included. The

temperature ranges from 0°C to 50°C. The YL-38 + YL-69, also known as a humidity hygrometer, can be used to monitor and detect moisture content. When the soil is wet, the output voltage drops, and when the soil is dry, the output voltage rises. The TEMT6000 is a light intensity sensor that detects how much light the plant receives. These sensors collect data about the plant's environment and send it to the Arduino UNO.

The Arduino UNO microcontroller is used in this project, which acts as a microcontroller that can be controlled remotely and transfers data using Ethernet Shield or Wi-Fi shield. The Ubidots IoT Cloud platform then offers data storage and charting services. Based on Figure 2.3, The sensors were interfaced with an Arduino UNO, which were then Wi-Fi connection to the cloud platform.

As demonstrated in Figure 2.4, It enables the user to create a dashboard and visualize the data in a graph format.



Figure 2.3 Configuration of Ubidots ID



Figure 2.4 Dashboard for the Ubidots cloud platform

2.3.5 Automated Plant Watering System

M. Astutiningtyas [16] in his paper Automated Monitoring and Control System, which was published in the journal 2021, proposes a design for an automation plant's watering system used in small gardens in the house. In general, at home, there is space in the front and back yards that can be used for small gardening. However, the space is in no way suitable for gardening. Then, due to their busy schedules, many people did not have enough time to water their plants. All plants will wither and be damaged if they do not receive enough water.

The researcher then employs a clever approach to managing the solution to improve crop production. Even in advance weather conditions, the researchers improve by increasing the efficiency of the watering system. Because different plants require different amounts of water, an intelligent system based on sensors and actuators was required.

By the journal Automatic Watering System for Plants with IoT Monitoring and Notification[17], the plants receive adequate water for their growth, according to the findings of the researchers. The plant also requires adequate water volume because it will have a direct impact on it. According to the researcher, watering can be done manually or

automatically. As a result, they propose a watering system that can be adjusted according to soil moisture levels. The researcher integrates the sensors that will be used to control the sensors and connect the watering device to the internet via Wi-Fi using a Wemos D1 microcontroller as the processor. The researcher gathers information from open-ended interviews and calculates dates based on observations of the plant's water requirements.



Figure 2.5 The design of Automatic Watering System

2.3.6 Smart Plant Monitoring System using IoT

Srivenkatesan S, Surya R, Tamilvan K, and Madhavan P [18] have proposed a project. We used natural pesticides instead of chemical pesticides. The user can monitor the plant using image processing and IoT while considering environmental data such as humidity, insects, soil, and temperature. Image processing and photographs of leaves and stems are used in a plant recognition system. It uses images of leaves and stems that have been developed using image comparisons with previous plant images to identify plant changes in image processing. Infected plants are treated with a natural pesticide after the problems are discovered in the database.

K.Lakshmi and S.Gayathri[19] has also produced superior results in analysing plant photos to determine the plant's condition.

Thanks to the Phyton IDE editor, this system used the Raspberry Pi as the microcontroller, which controlled the entire system and sent information to the user about the plant's condition (see Figure 2.6). The L298N Motor Driver regulates the speed and direction of DC motors with a voltage range of 5 to 35 volts. The geared motors are controlled with the coding in place. A servo motor is a device that allows you to precisely push and rotate objects. As a result, the Pi Camera captures the plant's right and left sides, as well as the stems and leaves The Raspberry Pi camera module communicates with the protocol serial MIPI camera interface using high-definition videos and photographs. In this system, an ultrasonic sensor is used to measure the distance to an object using ultrasonic sound waves.

On both sides of the plant, the servo engine rotates the Pi camera. The Phyton coding then compares the captured image to the image in the database. If the two images are not identical, the problem is sent to the smartphone.



Figure 2.6 Proposed Block Diagram for an IoT-based Smart Plant Monitoring System

2.3.7 Internet of Things (IoT)

The main unit of this system is IoT (Internet of Things). Nowadays, IoT is widely used in the system because it wants to communicate between human interference with controlled devices, such as smart phone or tablet PCs with the internet. When the gardener or planter were far from house such as need to outstation for work, travelling or else usually the gardener or planter will check the plant using own smartphone. The smart plant monitoring system for agriculture has the potential to protect plants from climatic conditions while also providing optimal conditions for plant growth, resulting in an increase in crop quality. Traditional plant monitoring and control systems, on the other hand, are very expensive and have a poor user interface. As a result, it is low-cost and user-friendly, and this low-cost smart plant monitoring system for small and medium-sized areas can be implemented using cloud computing and IoT. The Android Studio and Firebase applications will be used to achieve these objectives.

An IoT-based plant monitoring system is proposed in this paper, IoT Based Plant Monitoring System [20]. The researcher used the Internet of Things (IoT) as a platform to improve accuracy, economic benefits, efficiency, and human intervention. The researcher uses an Arduino Uno as a microcontroller to control the sensor. In this project, the ESP 8266 Wi-Fi module was used to connect the microcontroller to the Wi-Fi connection. It was also used to send all sensor data to the server and monitoring platform. The researcher uses a service called Things Speak.



The paper then moves on to IoT-based plant monitoring and smart gardening system [5], proposes smart gardening and automatic plant monitoring system based on the Raspberry Pi platform. This researcher devises an easier to monitor and control system. A camera is also included in this system, which can be used to monitor the garden from a mobile device. The researcher used a Raspberry Pi to keep the system as low-cost as possible. The system keeps track of the temperature of the plant, soil moisture, humidity of the plant's environment, light intensity, and pH of the soil are all factors to consider. To provide a data monitoring view, this system employs numerical values, charts, and graphs.


2.3.8

Cloud computing is a network model that allows easy access to computing resources such as applications, services, networks, communication, servers, and storage that can be quickly released and provisioned with little effort or service interaction. Different perspectives on cloud computing exist, with the most common being that cloud computing is not a new technology like other technical terms, but rather a new operational model. All of these are combined as a package to run the business in a new way using existing technologies. Cloud computing makes use of a variety of technologies, including utilitybased pricing, virtualization, and demand, all of which are not new.

Cloud computing will assist in leveraging these existing technologies in order to meet the economic as well as technological demands of future information technology demand. It also focuses on effectively maximizing shared resources. Clients can access storage and services on demand thanks to cloud computing. The internet is used to provide access to these resources. It's also useful when a sudden need for these resources arises.

Firebase is a Backend-as-a-Service (Baas) It offers a variety of tools and services to developers to help them create high-quality apps, expand their user base, and profit and web app development platform owned by Google. Firebase is classified as a NoSQL database tool that saves data in JSON-like documents. In this case, firebase was used to accept data from the Node MCU, which collected data from multiple sensors and showed it on the mobile application. Watering the plant, turning on the UV light, and many more commands are automated from here. It helps to build better mobile applications. It gives functionalities like analytics, databases, messaging, and crash reporting.

It is built on Google infrastructure and scales automatically. It is easy to integrate firebase with iOS, Android, and the web. API's are packaged into a single SDK hence it can be expanded to more platforms. It provides a real-time database and backend service. The real-time values from the sensors are uploaded to firebase through Node MCU. The firebase is integrated with mobile apps for control purpose[11].

2.3.9 Arduino IDE Software

Arduino is essentially a mixture of hardware and software that functions as an opensource project (easily accessible by people over the internet). The hardware consists of a circuit board integrated with a programmable microcontroller, and the software is an IDE that allows you to develop and upload code. It supports the languages C and C++, which have unique code structure rules. Because the Arduino IDE is compatible with a wide range of circuit boards, that have combined it with the Node MCU board here. The program for Node MCU can be written in any programming language. The Arduino software provides a better Integrated Development Environment (IDE) for programming the Node MCU. It is a cross-platform application written in Java. This software consists of various features which include code editor, text cutting and pasting, replacing text and searching, brace matching, automatic indenting, and syntax highlighting. The board in the software should be changed to Node MCU from Arduino and the libraries for Node MCU should be included in the software. The board is test with a blinking LED program and then the program for the smart garden is written. The library files for firebase connectivity are included in the program. The program known as the sketch is saved with file extension.ino.

2.3.10 Mobile Application Android Studio

In other smart plant monitor used android application only. However, the user that using iOS version cannot be access. JetBrains has created an open-source Integrated Development Environment for developing Android applications. This software runs on Windows, Mac OS X, and Linux. It has several features that allow users to create Android apps with a better user interface. Java, Kotlin, and Python are among the programming languages supported. It has Android Virtual Device, which can be used to run and debug apps in Android Studio. The implementation programmed for the Garden app is written in Java, while the code for the designing part is written in XML.

In the implementation phase, the firebase connectivity is also completed. This app has two screens: a login screen and a home screen. It is made up of various events that are used to automate the Smart Garden. This mobile application allows the user to monitor and control the Smart Garden System remotely or locally. When the sensor's values exceed the maximum or threshold value, the user is notified via push notifications and can take control of the system from a remote location. Because it is open source, this method is inexpensive.

2.3.11 General Requirements in Growing Chili Plants

Chili, or Capsicum annum L, is a tropical and subtropical plant in the Solanaceae family that is grown for its fleshy fruits. Chili plants can be grown year-round indoors in a planter box with artificial light. If the days become shorter or there is insufficient light in the space, the chili plant should be supplemented with artificial plant light with daylight white illumination, which is effective in simulating sunlight. Additionally, if the plant is exposed to direct sunlight for an extended period, especially during flowering, the plant may become dried out.

According to Krubong Melaka, the owner of MS Gardening (UT0017705-A), chili plants require well-drained soil, as shown in Figure 2.8. An organic soil-based compost containing micro, coco peat, red-burnt soil, fine sand, old humus, and charcoal is suitable for chili plants. This type of soil compost is lightweight but easy to re-wet when it dries. The soil-based compost also has excellent drainage, a pH balance, and a high nutritional content.



Figure 2.9 Mix organic soil that used for chili

Chili plants can also be grown indoors under grow lights if they are exposed to at least 8 hours of light per day. Chili plants, on the other hand, aren't picky about how much light they get because they're not sensitive to the amount of time they're exposed to it, and they can thrive under regular LED grow lights. For optimal light exposure, keep the lights close to the tops of the chili plants, but at least a few inches away to avoid scorching the top leaves.



Figure 2.10 Chili plant is placed indoor

Furthermore, if the chili plant is kept indoors, the lack of humidity could be the cause. For chili plants, a humidity level of over 50% is ideal. Chili plants will quickly wilt if the heating air is too dry. As a result, installing room fountains or a water basin in the space may help to improve the humidity levels.

Light is only used as a supporting device in this project to aid the growth of the chili plant. This light was used when the weather changed during the day, such as when it rained all day. Figure 2.11 depicts how a chili plant is placed indoors on a rainy day. Figure 2.11



Figure 2.11 Chili plant placed while climate change

2.4 Comparison between Literature

No	Title/	Problem	Solution/Mathods	Author	Voor
110.	Research / Source	Statement	Solution/ Methods	Autio	I eai
1.	Indoor	As water	Monitors plants	Aniruddha Gujar, Raj	
	Plant Monitoring	supplies become scarce	environment and tracks	Joshi, Avdhoot Patil, Prof.	
	System using	and polluted, there is an	environmental conditions,	Suvarna Aranjo	
	NodeMCU and Deep	urgent need to irrigate	helping the plants thrive		2020
	Learning	more efficiently to	using AlexNet monitor.		2020
	E	optimize water use to			
	143	support green			
		environment.			
2.	Smart	Agriculture	Watering system	Mithya V, Aishwarya	
	Gardening	farming's limitations in	with an automated watering	M, Gayathri S, Mahalakshmi L	2010
		terms of water supply to	system and a GSM system	S, Pavithra S.	2019
	UNIV	plants TEKN	monitor. MALAYS	A MELAKA	
3.	Low Cost	Needs lot of	Monitoring plant	D. Sowmya, R.	
	and PI Based Smart	manual efforts required	system using Raspberry PI	Praveen Sam	2010
	Home Garden	for proper grow up the	and implement IoT concept		2019
			for monitoring		

	Watering System	seedlings and watering			
	using IOT	system.			
4.	Automatic	Daily activities	Design of the	Maria Beata Inka	
	Plants Watering	leave many people	Internet of Things for small	Astutiningtyas, Monika Margi	
	System for Small	without enough time to	gardens inside houses using	Nugraheni, Suyoto	
	Garden	water their plants	Wireless networks and		2021
	S.	Y.	sensors. In automatic		2021
	No.	XA	watering plants, information		
	H H	•	about soil moisture is needed		
	E		for plants		
5.	Plant	Growing busy	Introduced using	Ms. Yogeshwari	
	Watering and	life of people, taking	IOT sensors and cloud-based	Barhate, Mr. Rupesh Borse, Ms.	
	Monitoring System	care of plants and water	databases using GSM	Neha Adkar, Mr. Gaurav Bagul	2020
	Using IoT and Cloud	wastage in many cases.	module.	اوىيۇم سى	
	Computing); ;	11 W - 11 -	
6.	The	ERS Plant TEKN	Monitors and	Y Syafarinda, F	
	Precision	monitoring is carried	controls in greenhouse are	Akhadin, Z E Fitri, Yogiswara,	
	Agriculture Based	out manually with a	sensor networks and	B Widiawan, E Rosdiana	2018
	on Wireless Sensor	measuring instrument	actuators.		
		and comes to the			
1	1	1			

	Network with	location directly and the			
	MQTT Protocol	provision of plant			
		nutrition based on the			
		age of the plant, but this			
		does not fully suit the			
	2	needs of the plant.			
7.	Wireless	Tradition	Wireless sensor	Mr. Kunal Goel, Dr.	
	Sensor Network in	agriculture in get the	system with a few sensors	Amit Kumar Bindal	
	Precision	exact details about their	for measure the various		2018
	Agriculture: 🛃 A	cultivation land.	parameters of land.		
	Survey Report				
8.	Automatic	The process of	Provided	Jacquline M.S.	
	Watering System for	watering plants is	automated prototype and a	Waworundeng, Novian	
	Plants with IoT	generally done	system that have the function	Chandra Suseno, Roberth Ricky	2010
	Monitoring and	manually regardless of	of watering plants based on	Y Manaha	2019
	Notification	the volume of water	the soil moisture level	A MELAKA	
		needed by plants.			
9.	Cloud-	Crop	Intelligent	Thaer Thaher, Isam	
	based Internet of	consuming a lot of	irrigation framework based	Ishaq	2020
	Things Approach for	water to growth well	on Wireless Sensor Network		

	Smart Irrigation		(WSN) and Internet of		
	System: Design and		Things (IoT) cloud services		
	Implementation		using ThingSpeak system.		
10.	IoT based	Peoples facing	IoT based approach	Mubashir Ali, Nosheen	
	smart garden	problems in their	for smart garden monitoring	Kanwal, Aamir Hussain,	
	monitoring system	homegrown gardens	using NodeMCU	Fouzia Samiullah, Aqsa	
	using NodeMCU	regarding the	microcontroller	Iftikhar, Mehreen Qamar	2020
	microcontroller	maintenance and			
	i i i i i i i i i i i i i i i i i i i	availability of proper			
	E	gardeners			
11.	Smart	More plants	Maintain the nature	T.Thamaraimanalan,	
	Garden Monitoring	die due to lack of	of the plants by continuously	S.P.Vivekk, G.Satheeshkumar,	
	System Using IOT	maintenance	monitoring the parameters	P.Saravanan	2019
	XC	≤ل ماسسا م	leading with automatic	اوىتۇم سى	2018
			systems using android	1 V - 1-	
	UNIV	ERSITI TEKN	application.	A MELAKA	
12.	Smart Plant	Difficult to	Implementation of	Suraj Singh Thakur,	
	Monitoring System	monitor plant health	a smart plant monitoring	Pankaj Sharma, Dhritayman	2019
		with exact know the	system which makes use of	Sharma	2018
		status plant parameters.	the concept ambient		
1		1			

			intelligence with the use of		
			.Net Gadgeteer which,		
			proactively handles the plant		
			monitoring system		
13.	Tomen: A	Leak to	The automates	Ramkumar.E,	
	Plant monitoring and	maintain the quality of	plant monitoring and smart	Nagarani.S, Roger Rozario A.	
	smart gardening	plant	gardening using IoT in the	P, Arjuman Banu.S	
	system using IoT	KA	Raspberry Pi platform to		
	TE		provide comfort to the		2019
	E		people by reducing the		2018
	200		manual work and to improve		
	41	lwn -	the overall performance of		
	chil	1 11/	any system without the user	* 1	
	2XC	E alumit a	interaction.	اويوم سي	
14.	IoT Based	No plan for the	IoT in Automatic	Prof. Likhesh Kolhe,	
	Plant Monitoring	usage of water in farms,	watering system. Automatic	Prof. Prachi Kamble,	
	System	then it causes wastage	watering system monitors	Mr.Sudhanshu Bhagat,	2020
		of water and need to	and maintain the	Mr.Sohail Shaikh, Mr. Ronak	2020
		supply water	approximate moisture	Sahu, Miss.Swati Chavan,	
			content in soil.	Miss. Prajakta Zodge	
	1				

2.5 Summary

Plant monitoring has become easier and more efficient thanks to the Internet of Things (IoT), resulting in higher crop productivity and, as a result, higher grower profits. Wireless sensor networks and various types of sensors are used to collect data on crop conditions and environmental changes, which is then transmitted via the network to growers and devices that take corrective action. Growers can stay connected and informed about crop field conditions from any location. Some of the disadvantages of communication must be overcome by improving technology to use less energy and creating more user-friendly user interfaces.



CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will describe the processes and methods used in this project, as well as how the result is acquired in order to meet the project's goals. This chapter will also go over the project in detail, including the software development for a 'Smart Plant Monitoring Using IoT and Arduino: Software Development.' It includes detailed descriptions of the design to be used, hardware and software material selection, and data collection and analysis procedures. The entire system follows a specific flow path, which can be broken down into multiple steps depending on the various parts' functionalities.

3.2 Methodology

This project is a new mobile app that will run an integrated edible garden system. The system connects all data from the built-in monitoring system to the crop, as well as sensor-actuators to a management system that can work automatically or with human intervention. Furthermore, this project will receive periodic reports for real-time updates. This can be a personal app or a shared app with the community. For example, if they are working on a garden, The use of allows anyone to do simple work from anywhere with just one click.

3.3 **Project Architecture**

3.3.1 General Project Flow Chart

This is the project's general flow was established on the project's flowchart. The steps may be seen in the process diagram below:



3.3.2 Project Flow Chart TEKNIKAL MALAYSIA MELAKA

The flow chart depicts the development of a project from conception to completion. The research and information gathering stage, as well as the understanding of all programming languages, functional design, and production of IoT applications, are all referred to as pre-development. Following the pre-development phase, the first stage of development is to incorporate the data collection process into the Arduino coding. In addition, coding for IoT monitoring systems will be created as part of this procedure. During the post-development stage, the final stage of the simulation results output into hardware and applications is completed.



Figure 3.2 Project Flow Chart

3.4 Proposed System Design

This project has the following benefits and is supported by technologies such as IoT, data analysis, plant health monitoring, efficient soil moisture inspection, water level, humidity and pH level for water. This approach is great for growers who want to keep their crops at home but are too busy with their daily activities to do so. Growing a crop takes time and effort because there are several daily tasks that must be performed, such as watering it regularly, making sure the crop gets adequate lighting, and maintaining proper soil moisture. Growers tend to forget their crops. Furthermore, several growers work and are so busy with daily activities that they ignore crop demand.

In this case, the grower usually does not ask for help to treat his crop at home, so the grower simply ignores the health of the crop. This project is an antonym of plant monitoring that can assist growers in monitoring plant health. Further, because it can be operated remotely, growers may be notified through an application system, and it is easy for growers to identify the nutrients needed by the crop.

It is typically composed of a core microcontroller to which other items are linked. The smart monitoring system is built around a ESP32 that serves as a hub for various sensors such as moisture sensors, pH sensors, float switch and humidity sensor. Other sensors are linked to their appropriate placements, and the data from these sensors is sent to ESP32, which has an embedded Wi-Fi technology. Firebase is an internet-accessible database that updates real-time sensor information every second. Android applications are created with the help of the Android studio software. The connection between the application and Firebase will be established within the programmed. As a result, the user may monitor the parameters from any location. Watering a garden varies depending on the kind of soil. As a result, the sensor values are predefined for automation purposes within the programmed. When the user needs to water the garden, a switch in the app will automate the operation. This helps maintain the overall health of the crop.



Figure 3.3 System design

3.5 System Architecture

The essential principle behind the operation of this procedure is dependent on information from several sensors in the plant pot. The incoming input is assessed, and an output is carried out as a result to maintain the plant's health and ensure the overall success of the process.

Using the system, all data relating to soil moisture, pH level of water, humidity and water level was collected and then uploaded to the Firebase cloud. The data was then utilized to make the choice to alert the growers of the plant's state. The prototype is made up of a ESP32 that is linked to a relay module. In addition, the soil moisture sensor has been linked to the ESP32, which acts as the system's central unit. The relay is supplied by a 5V power supply. The block diagram of this project is presented in Figure 3.4.



Figure 3.4 Project Block Diagram

- a. Fetching sensor data is carried out every hour which is scheduled and controlled by the Arduino.
- b. The soil moisture sensor, humidity sensor, float switch and pH sensor of the plant runs to collect the data values.
- c. As soon as the data is received by the Arduino it sends the data values to the cloud (Firebase) by using the internet connection established with the help of the Wi-Fi module.
- d. The data in the mobile phone of the user receives or retrieves data from the cloud.The data received by the application is analyzed with the database (which relates to the mobile application) of the plant in the plant pot.
- e. Some plants require several hours of direct sunlight, but users may overlook the fact that excessive heat can also harm plants. The data collected by the humidity sensor is compared to the plant requirements stored in the database to assist in this situation, and the user is notified of the temperature received by the plant.
- f. Some plants require a good amount of soil moisture to grow well and whenever a humid environment is needed as per the analysis of data by the mobile application.

g. A good pH value of the water is also a significant factor in plant growth. A dangerous pH level is notified to the user, so, that the right action can be taken.

3.6 Hardware and Parameter

The hardware for the system is made up of the following components, which are programmed in the Arduino IDE and assembled on a breadboard with jumper wires to connect to a DC unit.

Furthermore, this system monitors soil moisture content, humidity, water pH level, and inside the water storage, there is a level of water. This section contains a list of the hardware that was used to measure the parameter.

3.6.1 Wi-Fi Based ESP-WROOM 32

The ESP32 can be purchased as a single module or as a full development board. Wi-Fi and Bluetooth wireless connectivity are available on the two-core development board. This processor serves as the system's brain, connecting all the system's inputs and outputs. It could read and control inputs like soil moisture sensors, pH sensors, humidity sensors, and float switches, and control and activate outputs like the motor pump. The Arduino IDE can be used to program this ESP32 to process inputs and data before sending it to the outputs.

Table 3.1 Features of Wi-Fi Based ESP-WROOM-32

No.	Features	Descriptions
1.	Voltage of Operation	2.7V to 3.6V
2.	DC Voltage Input	5 V – 12 V DC
3.	Wi-Fi	150 megabits per second
5.	Bluetooth	v4.2

8.	Temperature	-40°C to 85°C



Figure 3.6 Pin Label for Input and Output

3.6.2 Soil Moisture Sensor

The soil moisture sensor is a simple breakout that detects moisture in soil and other materials. The soil moisture sensor is easy to install and use. The sensor functions as a variable resistor when the two large, exposed pads are combined. The greater the conductivity between the pads when there is more water in the soil, the lower the resistance and the higher the SIG out. It's frequently used in greenhouses to manage water delivery and other bottle-related improvements. To monitor the water content of the soil, biologists are conducting research.



Figure 3.7 Flowchart of moisture and watering system

This sensor uses capacitance to determine the water content of the soil by detecting the dielectric permittivity of the soil. The fork-shaped probe inserted into the soil acts as a variable resistor, changing in response to the water content of the soil. Table 3.2 the moisture content of the soil has an inverse relationship with its resistance. Based on the measured resistance, the sensor then generates an output voltage.

When the soil is detected as being dry, this system measures soil moisture and automatically irrigates the plants. On the application, the water content of volumetric soil is displayed as a percentage.



Figure 3.8 Soil moisture sensor placed in soil to detect parameter

Table 3.2 Condition of soil moisture sensor

Water Condition	Resistance
More water is needed	Reduce your resistance
Water usage is reduced	Increased resistance

Based on Figure 3.9 depicts a typical soil moisture sensor, and the characteristics are shown below.



Figure 3.9 Soil Moisture Sensor

No.	Features	Descriptions
1.	Voltage of Operation	3.3 V to 5V
2.	Currently in Use	15mA
3.	Analog and digital output	0V to 5V
4.	PCB Dimensions	3.2cm x 1.4cm
5.	Advantages	 It's simple to use. Small. Cheap. Easily accessible
6.	Design based o	n the LM393 microcontroller

Table 3.3 Soil Moisture Sensor Module Features

3.6.3 pH Level Sensor

With a value ranging from 0 to 14, this pH sensor measures the acidity or alkalinity of water. The pH value of an acidic solution is less than 7, and the pH value of an alkaline solution is greater than 7. The purity of water is measured differently by each type of pH sensor. This sensor is used in this plant monitoring system to determine the proper water quality for chili plants, which is usually between 5 and 6.5 for roses. The pH of water can also reveal whether it is contaminated or not.



Figure 3.10 Placement of pH sensor on water tank



UNIVERSITFigure 3.11 pH scale color chart MELAKA



Figure 3.12 pH Level Sensor

No.	Features	Descriptions
1.	Module Power	5V
2.	Measuring Range	ر 14 pH -0 20 م
3.	Temperature Measurement	AL MALAYSI 0°C-60°C (A
4.	Accuracy	\pm 0.1 pH (25° C)
5.	Time to Respond	In under a minute
б.	Module Dimensions	43mm x 32mm
7.	Connector Types	BNC
8.	Potention	neter for adjusting gain
9.	p	H 2.0 interface

Table 3.4 Features of pH sensor



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

3.6.4

This submersible water pump has a relay that rotates and pushes water outwards.

This 5V active high relay is truly waterproof and sealed, and it is securely attached to the It is the body of the water pump that it controls. This lightweight, small-sized, low-noise water pump's primary function is to deliver water to the plants. This project necessitates an acceptable amount of water twice daily, for a total of 100ml per day. However, some plants have their own water requirements.



Figure 3.15 Mini Water Pump

Table 3.5 Features of motor pump

No.	Features	Descriptions
1.	Operating Voltage	3V to 6V (DC)
2.	Rate Water Flow	80 -100L/hour
3.	Operating Current	100mA – 200mA
4.	Maximum Lift	40mm – 100 mm
5.	Pressure	Low



Figure 3.16 Water Pump Description

3.6.5 Humidity Sensor

AALAYS!

The DHT22 is a relative humidity and temperature sensor with a digital output. Because this sensor can take new readings every 2 seconds, timing should be carefully considered. The DHT22 is the more expensive model, but it has superior specifications. It has a temperature measuring range of -40 to +125 degrees Celsius, with an accuracy of +-0.5 degrees and the DHT22 sensor has better humidity measuring range, from 0 to 100% with 2-5% accuracy. On this project DHT22 is indicator to detect the temperature and humidity in surrounding.



Figure 3.17 DHT22 sensor placement for humidity and temperature surrounding



Figure 3.18 DHT22

Table 3.6 Technical details of DHT22

No.	Features	Descriptions
1.	Power Supply	3V to 6V (DC)
2.	Output signal	Digital signal via 1-wire bus
3.	Sensing element	Sensing element
4.	Operating range	Humidity 0-100% RH Temperature -40~80Celsius
5.	Accuracy ماليسيا ماAccuracy UNIVERSITI TEKNIK	Humidity +-2% RH (Max +-5%RH) Temperature <+-0.5Celsius
6.	Resolution or sensitivity	Humidity 0.1% RH Temperature 0.1Celsius
7.	Repeatability	Humidity +-1% RH Temperature +-0.2Celsius
8.	Humidity hysteresis	+-0.3%RH
9.	Sensing period	Average: 2s
10.	Interchangeability	Fully interchangeable

3.6.6 Float Switch

The level of a liquid in a tank or container is detected by a float switch. A mechanical switch that floats on top of a liquid surface is known as a float switch. It moves vertically along with the liquid level as it rises or falls. The mechanical switch opens or closes depending on the counterweight and pre-set trigger. The switching operation is contactless, wear-free, and requires no power. This connected device usually either stops or starts the liquid inflow.

An internal switch, also known as a sensor, and a hollow floating body make up a float switch. The most common internal switch is a reed switch, which means there is a magnet inside the body. Other types of internal switches exist, but the principle is the same: gravity and the water level move the float switch vertically up or down, causing it to open and close. As a result, an electrical circuit is opened or closed by the mechanical switch.



Figure 3.19 Float Switch



Figure 3.20 Float switch is used to detect the level of water in water storage

3.7 Software Development

The software that will be used to complete the project will be discussed in this section. Software development is a method for creating software that involves a series of steps. Not only does the actual coding take place during this process, but it also includes the planning of specifications and goals, the specification of what will be programmed, and the assurance that the final product meets the goals.

Quality control ensures optimization, system restrictions, and testing grade[13]. These characteristics enable us to maintain a good check on things and set the bar for commercial use. Connectivity to any network, standalone usage without a mobile application, portability and charging capabilities, and so forth are important features[21].

To access and view the acquired data, the device needs an Android application. To access the data, the customer must first log in to the application. After authorization, growers can access real -time data of the device as well as factor profile history. Growers will automatically find the optimal conditions necessary for crop health. in this stage, using Android Studio to create specialized applications that run a full system for building mobile phones.

Technically, there is just one interface (user). The programmer is meant to collect data from the device and either shows it on the application or store it to the local host. The device's communication is based on a wireless network standard, and the HTTP standard is employed. Because the gadget will need an IP address to connect to a network. JSON responses will be sent between linked devices. If a network failure occurs, data will be stored on a local server and can be viewed later.

The physical configuration of its electrical components is combined with communication techniques that encompass the techniques and types of data transfer between the device and application in the proposed system. The implementation is divided into two parts:



Figure 3.21 System data flow

3.7.1 Arduino IDE Software (Integration Development Environment)

A code a text terminal, a message area, a common function toolbar, and an editor are all included. a menu system are all included in the Arduino Integrated Development Environment (IDE). It can run on Mac OS X, Windows, and Linux. Besides that, it could be used in the most common operating system, it is compatible and user-friendly. The framework is written in Java using Processing and other open-source tools. This programmer works with any Arduino board. The routines include and may then be uploaded to any Arduino board.

- 1. *Message area:* Saving and exporting feedback, as well as errors, are displayed.
- 2. *Text Terminal:* The Arduino software generates text, which includes detailed errors
- 3. *Toolbar functions:* Allows verify, upload programs, New/Create, Open, Save and open Serial Monitor.
 - ✓ Verify: While compiling the code, it checks for errors.
 - **UN** ✓ **Upload:** Compiles the code and uploads it to the board.
 - ✓ **New:** Creates new sketch.
 - ✓ Open: Displays a sketched menu. It will open the sketch and overwrite the content if you click it.
 - ✓ **Save:** Saves the sketch.
 - ✓ **Serial Monitor:** Activates the serial monitor.

Additional commands may be found in the File, Edit, Sketch, Tools, and Help menus. Arduino sketches are programmers written in the Arduino programming language (IDE). These drawings are made in a text editor and saved as files with the extension '.ino.' Any website may readily find the open-source code. The Arduino board may be used to upload the sketches.



3.7.2 Arduino Firebase as Internet of Thing (IoT)

Google's Firebase is a mobile and web app development platform. It aids in the development of better mobile applications. It includes features such as analytics, databases, messaging, and crash reporting. It is built on Google infrastructure and automatically grows. Firebase is simple to connect with iOS, Android, and the web. APIs are bundled into a single SDK, allowing it to be extended to support multiple platforms. It offers a real-time database

as well as a backend service. The sensors' real-time data are uploaded to firebase through Node MCU. For control purposes, the firebase relates to mobile apps.

Cloud Firestore is a versatile, scalable database from Firebase and Google Cloud for mobile, web, and server development. It, like Firebase Realtime Database, uses real time listeners to keep your data synchronized across client apps and provides offline support for mobile and web, allowing you to design responsive apps that run regardless of network latency or Internet access. Cloud Fire store also integrates seamlessly with other Firebase and Google Cloud technologies, such as Cloud Functions.



Figure 3.23 Firebase appearance

3.7.2.1 Dashboard Configuration (Firebase)

Smartphones are important on the Internet of Things because they can control and communicate with everyday devices through apps. Firebase is a web app that connects hardware to the cloud and analyses data from devices in real time. Hence, it can be remotely control from anywhere in the world and get notifications. In this project, Firebase is the data transmit for user before it receives on smartphone to display data about the plant's condition on the application.

Before configurate further on mobile dashboard (Android Studio) and web dashboard (Firebase.Cloud), a latest version of Firebase ESP32 Library is installed to the Arduino IDE. Then, the Firebase ESP32 folder is shown under File > Examples. To activate Firebase Cloud and sync it with Android Studio Apps, a device should have a unique AuthToken, which is a main identifier of the device in the Firebase Cloud.

#define FIREBASE_HOST "https://smart-plant-monitoring-s-9ff33-default-rtdb.asia-southeast1.firebasedatabase.app/"
#define WIFI_SSID "_nrfadzlh"
#define WIFI_PASSWORD "fxzdsn97"
#define FIREBASE Authorization key "huEDQLGNnqf6s2L2WTOKhcPgdAZjDXIFp20g0GsM"

Figure 3.24 Template ID, Device Name and AuthToken

3.7.3 Android Studio as Interface Application

Android Studio was first announced at Google I/O in 2013. Previously, I used Android Developer Tools (ADT). ADT is an Android development environment based on Eclipse, a free and open-source integrated development environment. JetBrains and Google

Android development is made easier with the Android Studio. As a result, it has been designated as the official Android IDE. Java is the foundation of Android Studio. In many ways, Java is a very useful and popular programming language. Memory management is the most important reason for using Java. This eliminates the need for programmers to consider the use of stacked memory or the release of memory after it has been used. The Android Studio environment, like Java, is a memory management programming environment.
Android Studio was used to develop the app. Is indeed the section that connects the app to Google Firebase, which is where the sensor data is gathered. Attachments with the name MainActivity.java contain part of the code for linking text written in activity main.xml (displayed in the application) and Google Firebase. The xml file is also in the attachments.

The activity main.xml layout file is in the res or layout directory and is used by your application to create its interface. It can make numerous changes to this file as application's layout evolves.



Figure 3.25 Display application on Android Studio

A Java file named MainActivity.java contains the code for the main activity. This is the actual application file that is eventually converted to a Dalvik executable and runs your program. The default code for Hello World! generated by the application wizard is as follows. Moreover, it can rewrite as system that in build. To begin, MainActivity.java contains most of the code (as mentioned, it did have the option to change this when creating your new app project). The first activity's code is as follows: the app's initial screen.





3.8 Electrical Hardware Connection



CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and discussion on the data collected from the Firebase cloud and Android Studio apps in detailed. The data collected are soil moisture content, pH value of water and humidity and temperature surrounding due to the chili plants. The time taken for the data collection are around two weeks. Any changes on the chili plant were observed and recorded.

4.2 Test Result in Software

4.2.1 Design In Proteus

On this part, it showed the design of the system in Proteus software to test the UNIVERSITI TEKNIKAL MALAYSIA MELAKA system that had been constructing in the preliminary stage which is to test the system without using Firebase and Android Studio. Therefore, in proteus the system using Arduino Uno as representing ESP32.

The soil moisture sensor is representing as a button switch. When the button switch was a push, the LCD will appear as the result of the soil moisture status and light intensity. In the preliminary stage, all the real component was replaced with compatible in proteus such as LCD representing the mobile application, switch button represented as the soil moisture sensor. The LED used here to represent the indicator for light and motor as a watering pump.



Figure 4.1 Design monitoring system in Proteus

4.2.2 Design Result Simulation based Proteus Software

In the beginning, the LCD will display 'GreeNic' and 'PSM_B0818110211' as

13 9

shown in Figure 4.2. This display output was set on the program code in Arduino IDE software.



Figure 4.2 LCD display

Next, after the delay in 1 second, the display will change to read the moisture of the soil. As a display, 'Moisture Soil' either it is in-state low or high. This moisture sensor in the simulation used a push-button to represent the real moisture sensor.

LCD1 Output Display
Moisture Soil:
LOW
VSS VVDD VVDD 01 01 02 02 03 02 03 02 03 02 03 03 03 03 03 03 03 03 03 03 03 03 03
22 = 2 123

Figure 4.3 Moisture Soil status

Furthermore, the water tank level will appear after the moisture soil reading status on the display. This status will read the same goes with the moisture of soil concept which is low or high. The LCD 'Water Tank Lvl'. for the water tank level, this project was used float switch in the real situation but in the simulation, it used a push button.

اليسيا ملاك	ويور سيني نيڪنيڪو MO41L Output Display
UNIVERSITI	EKNIKAL MALAYSIA MELAKA Water Tank Lvl: LOW
l	1 VSS 2 V VEE 3 V VEE 4 A RSS 4 A R

Figure 4.4 Water Tank Level Status

Although, the motor will operate when the moisture of the soil is low, and the water tank level is high. The LCD indicator will appear 'ALERT', 'Plant is Dry', and 'Pump Initiate'. the motor will start move after a 1-second delay. The motor here represents the water pump for the automatic watering plant. Frankly, the LED for D3 will turn on as shown the water tank level is high and the D2 as represent moisture status was off. As well as the LCD the status of moisture and water level.

In another way, when the water tank level is low and moist soil is low the motor will not operate, and when the water tank is low, and the moisture is high the motor will not operate. The motor will stop after the soil moisture sensor detects that soil is moisture.



Figure 4.5 Motor operating



In another way, when the water tank level is high and moisture soil is high the motor will be automated off operate. The motor will stop after the soil moisture sensor detects that soil is moisture.

4.3 Results and Analysis

4.3.1 System Functionality

The system will run when various sensors that have been assembled with hardware collect data and send it to the Firebase cloud in a real-time database. Furthermore, Firebase cloud and android application when the various sensors are combined, the plant can communicate with the user. It aids in the reduction of the plant owner's responsibility.

However, this system already been set up using Arduino IDE to trig the hardware component with several variable before the system run up and collect the data from the real crop. This smart plant monitoring assist user to keep update the condition of the plant in real time.

Meanwhile, the planter or the user need to know the characteristics of their own plant. Every plant has their own parameter and distinct requirements to meet the plant's growing requirements The plants used in this system are more suitable for outdoor use, but some people also grow these plants indoors. We can demonstrate that the plant can still be grown in the house using this system, which was built to see the parameters that were set for users to get information about the plant's needs.

4.3.2 Parameter Measured Results

Soil moisture, humidity, and temperature of the surrounding environment as indicators, pH level for water storage, and last water level in water storage are all parameters that have been measured in this system based on the plant. This parameter will be displayed in two ways: it will be collected and sent to Firebase as a real-time database, and it will be displayed in a mobile app as an interface to users using Android Studio.

The result will be displayed on the serial monitor in the Arduino IDE. The data will be collected in the same way as Firebase, which is the plant's real data.

💿 COM7

```
Temperature: 30.20°C Humidity: 72.60%
1023
Water Level is HIGH
Moisture : 1%
Turn ON Pump
Status: Soil is too dry - time to water!
```

Figure 4.7 The data reading in serial monitor



On this part, it showed the parameter result from system that have been sent to the data receive at Firebase cloud based on the real time data that collect from real hardware based on real plant. ERSITITEKNIKAL MALAYSIA MELAKA

Rea	Realtime Database								
Data	Rules	Backups	Usag	le					
				Ð	https://test-run-d84b0-default-rtdb.firebaseio.com/				
				test	-run-d84b0-default-rtdb ESP32_APP Humidity SoilMoisture Temperature WaterLevel				
					o WaterPump o pHLevel				



Moreover, when the data collect the parameter will show the status of the plant



Figure 4.9 The result based on real time

As Figure 4.9 shown, the data will collect based on the parameter that had been set. Furthermore, the reading of the data will read in digital state which is basically in digital system it will read as two condition "0" or "1". Based on water level and soil moisture data it collects reading in digital state.

When the result in Firebase for water level is "1," it means the water level is high or full. Although for soil moisture, it different with water level because when the soil moisture sensor detect soil was wet the result in Firebase will be "0" which is soil moisture is perfect condition while when the result is "1" the soil is dry and need water.

In this case, the water pump will trig when the soil moisture reading is dry which is "1" and start automated irrigation until the soil turn wet. Besides that, for humidity and temperature the reading will collect based on the current situation. It will keep changing when the surrounding condition changes.



Figure 4.10 Analysis from Realtime database in December 2021



Figure 4.11 Analysis from Realtime database in January 2022

The data from the

4.3.4 Android Studio Results Interface

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Android studio is the medium for user to monitor their plant which is the data receive from Firebase. On this part, it showed the result from the data receive at Firebase cloud based on the real time database will appear in interface of mobile application.

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Figure 4.12 Mobile Interface from Android Studio

The android studio has built with the design that will appearance on the mobile phone user. The design has been set based on the result on the Firebase.



Figure 4.13 Design in Android Studio

4.4 Summary

This This system can be implemented using basic software but there is still a lot to change according to the suitability of the actual system that has been planned. However, at this early stage it has been proven that key parameters are capable of being tested. This system has made monitoring agricultural crops easy and efficient. Some of the shortcomings found during this initial testing must be overcome by using better system settings.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This Smart Plant Monitoring System Using IoT and Arduino based on software development will consist of software and hardware development. Further, although it seems more demanding and difficult, there are many additional alternatives, such as building contacts or going out with various sensors, motors, batteries, and other equipment of similar types in the project available to complete the project. Some specific modifications or adjustments can be made on this device as the main purpose of this project is to provide a special daily monitoring system. In addition, this monitoring system also facilitates growers in using the provided applications to be able to obtain the status of their crops. In addition, the device is developed by design with monitoring such as water pH value, automatic watering system, humidity, and temperature for surrounding reading as well as soil moisture level and low cost with various functions. However, this will be the beginning of the process of developing a crop health monitoring system as well as making it easier for growers to monitor their crops. Finally, there is a lot more work that can be done in the future.

5.2 Future Works

According to the findings of Chapter 4, this app is still far from perfect, even though the basic objectives have been met. However, there has been little progress toward those goals other than the addition of more effective and practical information. This system can be used once to boost crop progress, with the option of fertilizing on a regular basis depending on the crop's suitability. Furthermore, by responding to crop problems such as a lack of minerals in the soil, the cause of crop damage, and others, this system can be upgraded to a higher system.

This can definitely be implemented in the future, in addition to current technology that has produced a lot of research in helping people live a better life.



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APPENDICES

Appendix A Datasheet of ESP-WROOM-32

1. OVERVIEW

Overview

ESP32-WROOM-32 (ESP-WROOM-32) is a powerful, generic WI-R+BT+BLE MCU module that targets a wide variety of applications, ranging from low-power sensor networks to the most demanding tasks, such as voice encoding, music streaming and MP3 decoding.

At the core of this module is the ESP32-D0WDQ6 chip*. The chip embedded is designed to be scalable and adaptive. There are two CPU cores that can be individually controlled, and the clock frequency is adjustable from 80 MHz to 240 MHz. The user may also power off the CPU and make use of the low-power co-processor to constantly monitor the peripherals for changes or crossing of thresholds. ESP32 Integrates a rich set of peripherals, ranging from capacitive touch sensors, Hall sensors, SD card Interface, Ethernet, high-speed SPI, UART, I2S and I2C.

Note:	APLATSIA
* For details on t	part number of the ESP32 series, places refer to the document ESP32 Detasheet.

The integration of Bluetooth, Bluetooth LE and WI-FI ensures that a wide range of applications can be targeted, and that the module is tuture proof: using WI-FI allows a large physical range and direct connection to the internet through a WI-FI router, while using Bluetooth allows the user to conveniently connect to the phone or broadcast low energy beacons for its detection. The sleep current of the ESP32 chip is less than 5 μ A, making it suitable for battery powered and wearable electronics applications. ESP32 supports a data rate of up to 150 Mbps, and 20.5 dBm output power at the antenna to ensure the widest physical range. As such the chip does offer industry-leading specifications and the best performance for electronic integration, range, power consumption, and connectivity.

The operating system chosen for ESP321s freeRTOS with LwIP; TLS 1,2 with hardware acceleration is built in as well. Secure (encrypted) over the air (OTA) upgrade is also supported, so that developers can continually upgrade their products even attactner release. EKNIKAL MALAYSIA MELAKA

Table 1 provides the specifications of ESP32-WROOM-32 (ESP-WROOM-32).

Categories	Items	Specifications
	RF certification	FCC/CE/IC/TELEC/KCC/SRRC/NCC
Continuation	WI-FI certification	WI-FI Allance
Certification	Bluetooth certification	BQB
	Green certification	RoHS/REACH
		802.11 b/g/n (802.11n up to 150 Mbps)
WI-FI	Protocols	A-MPDU and A-MSDU aggregation and 0.4 μs guard
		Interval support
	Frequency range	2.4 GHz ~ 2.5 GHz
	Protocols	Bluetooth v4.2 BR/EDR and BLE specification
		NZIF receiver with -97 dBm sensitivity
Bluetooth	Radio	Class-1, class-2 and class-3 transmitter
		AFH
	Audio	CVSD and SBC

Table 1: ESP32-WROOM-32 (ESP-WROOM-32) Specifications

1. OVERVIEW

Categories	Items	Specifications				
		SD card, UART, SPI, SDIO, I2C, LED PWM, Motor				
	Module Interface	PWM, I2S, IR				
		GPIO, capacitive touch sensor, ADC, DAC				
	On-chip sensor	Hall sensor, temperature sensor				
	On-board clock	40 MHz crystal				
	Operating voltage/Power supply	2.7 ~ 3.6V				
Hardware	Operating current	Average: 80 mA				
	Minimum current delivered by	500 mA				
	power supply					
	Operating temperature range	-40°C ~ +85°C				
	Ambient temperature range	Normal temperature				
	Package size	18±0.2 mm x 25.5±0.2 mm x 3.1±0.15 mm				
	WI-FI mode	Station/SoftAP/SoftAP+Station/P2P				
	WI-FI Security	WPA/WPA2/WPA2-Enterprise/WPS				
	Encryption	AES/RSA/ECC/SHA				
	Elmavoro unorado	UART Download / OTA (download and write firmware				
Software	ALAYS/A	via network or host)				
	Software developtright	Supports Cloud Server Development / SDK for cus-				
8	Contrate development	tom firmware development				
3	Network protocols	IPv4, IPv6, SSL, TCP/UDP/HTTP/FTP/MQTT				
	User configuration	AT Instruction set, cloud server, Android/IOS app				

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Electrical Characteristics 5.

Note:

The specifications in this chapter have been tested under the following general condition: VDD = 3.3V, T_A = 27°C, unless otherwise specified.

5.1 Absolute Maximum Ratings

Table 5: Absolute Maximum Ratings

Parameter	Symbol	Min	Тур	Max	Unit
Power supply	VDD	2.7	3.3	3.6	V
Minimum current delivered by	1	0.5	_	-	Δ
power supply	'V DD				
Input low voltage	V _{IL}	-0.3		0.25×V ₁₀ 1	v
Input high voltage	VIII	0.75×V ₁₀ 1		V ₁₀ ¹ +0.3	V
Input leakage current	III.	-		50	nA
Input pin capacitarioe	Cpady	1	-	2	pF
Output low voltage	VOL	-	-	0.1×Vro ¹	V
Output high voltage	VON	0.8×V ₁₀ 1			v
Maximum output drive capability	IM AX	-	-	40	mA
Storage temperature range	TSTR	-40	-	85	°C
Operating temperature range	Тоги	-40		85	°C

1. V₁₀ is the power supply for a specific pad. More details can be found in the ESP32 Datasheet, Appendix IO_MUX. For example, the power supply for SD_CUK is the VDD_SDIO: سيني - aug

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Table 6: WI-FI Radio Characteristics

Description	Min	Typical	Max	Unit
Input frequency	2412	-	2484	MHz
Input reflection	-	-	-10	dB
	Tx power			
Output power of PA for 72.2 Mbps	13	14	15	dBm
Output power of PA for 11b mode	19.5	20	20.5	dBm
	Sensitivity	r		
DSSS, 1 Mbps	-	-98	-	dBm
CCK, 11 Mbps		-91	-	dBm
OFDM, 6 Mbps	-	-93	-	dBm
OFDM, 54 Mbps	-	-75	-	dBm
HT20, MCS0	-	-93	-	dBm
HT20, MCS7		-73	-	dBm

5. ELECTRICAL CHAPACTERISTICS

Description	Min	Typical	Max	Unit	
HT40, MCS0	-	-90	-	dBm	
HT40, MCS7	-	-70	-	dBm	
MCS32	-	-89	-	dBm	
Adjacent channel rejection					
OFDM, 6 Mbps	-	37	-	dB	
OFDM, 54 Mbps	-	21	-	dB	
HT20, MCS0	-	37	-	dB	
HT20, MCS7	-	20	-	dB	

5.3 BLE Radio

5.3.1 Receiver

WALAYS/4						
Table 7: I	Receiver Characteristics -	BLE				
Drenmater S	Conditions	Min	Tim	May	List	
Palaliela 2	CONCIDENTS	-WEI	IAh	Inicia.	Unit	
Sensitivity @30.8% PER	- / /	-	-97	-	dBm	
Maximum received signal @30.8% PER	-	0	-1/	-	dBm	
Co-channel C/I		-	+10	-	dB	
ALNO .	F = F0 + 1 MHz	-	-5	-	dB	
shell I I	F = FO - 1 MHz		-5 1	-	dB	
Admont channel colocitativ City	F=F0+2MHz	م من ج	/25	21	dB	
Adjabent charnel selectivity con-	F = F0 - 2 MHz	-	-35	-	dB	
UNIVERSITI TEK	FH FOA 3 MHZALAYS	HA M	-25 A K	A	dB	
	F = F0 - 3 MHz	-	-45	-	dB	
	30 MHz ~ 2000 MHz	-10	ł	-	dBm	
Out-of-band blocking performance	2000 MHz ~ 2400 MHz	-27	-	-	dBm	
	2500 MHz ~ 3000 MHz	-27	ł	-	dBm	
	3000 MHz ~ 12.5 GHz	-10	1	-	dBm	
Intermodulation	-	-36		-	dBm	

5.3.2 Transmitter

Table 8: Transmitter Characteristics - BLE

Parameter	Conditions	Min	Тур	Max	Unit
RF transmit power	-		0	-	dBm
Gain control step	-	-	* 2	-	dBm
RF power control range	-	-12	-	+12	dBm

5. ELECTRICAL CHARACTERISTICS

Parameter	Conditions	Min	Тур	Max	Unit
	F = F0 + 1 MHz	-	-14.6	-	dBm
	F = F0 - 1 MHz	-	-12.7	-	dBm
	F = F0 + 2 MHz	-	-44.3	-	dBm
Adjacent channel transmit newsr	F = F0 - 2 MHz	-	-38.7	-	dBm
Aujacani channa bansinii power	F = F0 + 3 MHz	-	-49.2	-	dBm
	F = F0 - 3 MHz	-	-44.7	-	dBm
	F = F0 + > 3 MHz	-	-50	-	dBm
	$F=F0\to3\;MHz$	-	-50	-	dBm
∆ f1avg	-	-	-	265	kHz
Δf_{2max}	-	247	-	-	kHz
$\Delta f_{2avg}/\Delta f_{1avg}$	-	-	-0.92	-	-
ICFT	-	-	-10	-	kHz
Drift rate	-	-	0.7	-	kHz/50 µs
Drift	-	-	2	-	kHz



Figure 2: Reflow Profile



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1. Feature & Application:

- * Full range temperature compensated * Relative humidity and temperature measurement
- * Calibrated digital signal *Outstanding long-term stability *Extra components not needed
- * Long transmission distance * Low power consumption *4 pins packaged and fully interchangeable

2. Description:

DHT22 output calibrated digital signal. It utilizes exclusive digital-signal-collecting-technique and humidity sensing technology, assuing its reliability and stability. Its sensing elements is connected with 8-bit single-chip computer.

Every sensor of this model is temperature compensated and calibrated in accurate calibration chamber and the calibration-coefficient is saved in type of programme in OTP memory, when the sensor is detecting, it will cite coefficient from memory.

Small size & low consumption & long transmission distance(20m) enable DHT22 to be suited in all kinds of harsh application occasions.

Single-row packaged with four pins, making the connection very convenient.

3. Technical Specification:

Model 😸 👘	DHT22
Power supply	3.3-6V DC
Output signal	digital signal via single-bus
Sensing element (1)	Polymer capacitor
Operating range	humidity 0-100%RH; / temperature -4080Celsius
Accurry) to turn	humidity +-2%RH(Max +-5%RH); temperature <+-0.5Celsius
Resolution or sensitivity	humidity 0.1%RH; temperature 0.1Celsius
Repeatability	humidity +-1%RH; temperature +-0.2Celsius
Humidity hysteresis S	H-0.3% RHIKAL MALAYSIA MELAKA
Long-term Stability	+-0.5%RH/year
Sensing period	Average: 2s
Interchangeability	fully interchangeable
Dimensions	small size 14*18*5.5mm; big size 22*28*5mm

4. Dimensions: (unit---mm)

1) Small size dimensions: (unit----mm)

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Pin sequence number: 1 2 3 4 (from left to right direction).

Pin	Function
1	VDDpower supply
2	DATAsignal
3	NULL
4	GND

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5. Electrical connection diagram:



6. Operating specifications:

(1) Power and Pins

Power's voltage should be 3.3-6V DC. When power is supplied to sensor, don't send any instruction to the sensor within one second to pass unstable status. One capacitor valued 100nF can be added between VDD and GND for wave filtering.

(2) Communication and signal

Single-bus data is used for communication between MCU and DHT22, it costs 5mS for single time communication.

Data is comprised of integral and decimal part, the following is the formula for data.

DHT22 send out higher data bit firstly!

DATA=8 bit integral RH data+8 bit decimal RH data+8 bit integral T data+8 bit decimal T data+8 bit check-sum If the data transmission is right, check-sum should be the last 8 bit of "8 bit integral RH data+8 bit decimal RH data+8 bit integral T data+8 bit decimal T data".

When MCU send start signal, DHT22 change from low-power-consumption-mode to running-mode. When MCU finishs sending the start signal, DHT22 will send response signal of 40-bit data that reflect the relative humidity

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and temperature information to MCU. Without start signal from MCU, DHT22 will not give response signal to MCU. One start signal for one time's response data that reflect the relative hum idity and temperature information from DHT22. DHT22 will change to low-power-consumption-mode when data collecting finish if it don't receive start signal from MCU again.

1) Check bellow picture for overall communication process:



2) Step 1: NCU send out start signal to DHT22. AL MALAY SIA MELAKA

Data-bus's free status is high voltage level. When communication between MCU and DHT22 begin, program of MCU will transform data-bus's voltage level from high to low level and this process must beyond at least 1ms to ensure DHT22 could detect MCU's signal, then MCU will wait 2040us for DHT22's response.

Check bellow picture for step 1:

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When DHT22 detect the start signal, DHT22 will send out low-voltage-level signal and this signal last 80us as response signal, then program of DHT22 transform data-bus's voltage level from low to high level and last 80us for DHT22's preparation to send data.

Check bellow picture for step 2:

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Step 3: DHT22 send data to MCU

When DHT22 is sending data to MCU, every bit's transmission begin with low-voltage-level that last 50us, the following high-voltage-level signal's length decide the bit is "1" or "0".

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Check bellow picture for step 3:

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If signal from DHT22 is always high-voltage-level, it means DHT22 is not working properly, please check the electrical opprection status. TI TEKNIKAL MALAYSIA MELAKA

7. Electrical Characteristics:

Item	Condition	Min	Typical	Max	Unit
Power supply	DC	3.3	5	6	v
Current supply	Measuring	1	4 T	1.5	mA
	Stand-by	40	Null	50	uA
Collecting period	Second		2		Second

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*Collecting period should be :>2 second.

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