DEVELOPMENT OF SMART WATER IRRIGATION SYSTEM BASED ON SOIL MOISTURE SENSOR BY USING ARDUINO

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DEVELOPMENT OF SMART WATER IRRIGATION SYSTEM BASED ON SOIL MOISTURE SENSOR BY USING ARDUINO

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

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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 Electronics Engineering Technology (Telecommunications) with Honours.

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DEDICATION

Alhamdulillah, praise to the Almighty Allah S.W.T

This thesis is dedicated to:

My beloved parents Mohideen Bin Mahbat and Mariam Binti Bairi. To my brothers and sister, Mohd Dzul Fitri, NurHanim and Hanis Zulaiqa. A big appreciate to my supervisor, Madam Siti Asma Binti Che Aziz.

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ABSTRACT

The global technology of today is crucial to the agricultural industry. One of the most general and beneficial smart systems is an irrigation system that is built and implemented using sensor-based technology. People will get advantages from this in their regular activities, saving them time and effort. The problem statement for this system is utilizing contemporary technology to optimize irrigation techniques in order to address the pressing problem of water waste in agriculture. By incorporating weather forecasts, real-time data, and user inputs, this system can offer farmers a reliable and effective solution that will help them conserve water and increase agricultural productivity. The main objective of this project is to design a Smart Water Irrigation System (SWIS) that optimizes the use of water in agricultural activities by utilizing contemporary technologies. In addition to ensuring that crops receive the proper amount of water at the right time, this method seeks to minimize water waste and save expenses. This system combines sensor technology with a battery, DC motor, and microcontroller. The emergence of controlled environment agriculture (CEA), which includes ventilation, lighting, and computer-controlled irrigation systems, has altered the traditional farming environment. Other than that, the developed system manages several environmental variables, including soil moisture sensor. An Arduino is used to control soil moisture sensor and integrated to water pump and receive data. In conclusion, by optimizing water usage, the SWIS supports resource conservation and advances environmental sustainability. Furthermore, small-scale farmers may access the system due to the scalability and affordability of Arduino-based technology, which gives them the tools they need to improve productivity and lessen the effects of climate change on agricultural practices. The article suggests and illustrate a low-cost, user-friendly Arduino-based controlled watering system. This project mainly consists of three parts, which is detection of soil moisture level, auto pumping of water upon the low soil moisture level and the data logging of soil moisture level in percentage into Parallax Data Acquisition tool (PLX-DAQ) software add in for Microsoft Excel.

ABSTRAK

Teknologi global masa kini adalah penting kepada industri pertanian. Salah satu sistem pintar yang paling umum dan bermanfaat ialah sistem pengairan yang dibina dan dilaksanakan menggunakan teknologi berasaskan sensor. Orang ramai akan mendapat kelebihan daripada ini dalam aktiviti tetap mereka, menjimatkan masa dan usaha mereka. Penyataan masalah bagi sistem ini adalah menggunakan teknologi kontemporari untuk mengoptimumkan teknik pengairan bagi menangani masalah mendesak sisa air dalam pertanian. Dengan menggabungkan ramalan cuaca, data masa nyata dan input pengguna, sistem ini boleh menawarkan petani penyelesaian yang boleh dipercayai dan berkesan yang akan membantu mereka menjimatkan air dan meningkatkan produktiviti pertanian. Objektif utama projek ini adalah untuk merekabentuk Sistem Pengairan Air Pintar (SWIS) yang mengoptimumkan penggunaan air dalam aktiviti pertanian dengan menggunakan teknologi kontemporari. Di samping memastikan tanaman menerima jumlah air yang sesuai pada masa yang sesuai, kaedah ini bertujuan untuk meminimumkan pembaziran air dan menjimatkan perbelanjaan. Sistem ini menggabungkan teknologi sensor dengan bateri, motor DC dan mikropengawal. Kemunculan pertanian persekitaran terkawal (CEA), yang merangkumi pengudaraan, pencahayaan, dan sistem pengairan terkawal komputer, telah mengubah persekitaran pertanian tradisional. Selain itu, sistem yang dibangunkan menguruskan beberapa pembolehubah persekitaran, termasuk sensor kelembapan tanah. Arduino digunakan untuk mengawal sensor kelembapan tanah dan disepadukan ke pam air dan menerima data. Kesimpulannya, dengan mengoptimumkan penggunaan air, SWIS menyokong pemuliharaan sumber dan memajukan kelestarian alam sekitar. Tambahan pula, petani berskala kecil boleh mengakses sistem ini disebabkan oleh skalabiliti dan kemampuan teknologi berasaskan Arduino, yang memberikan mereka alat yang mereka perlukan untuk meningkatkan produktiviti dan mengurangkan kesan perubahan iklim ke atas amalan pertanian. Artikel itu mencadangkan dan menggambarkan sistem penyiraman terkawal berasaskan Arduino yang kos rendah dan mesra pengguna. Projek ini terutamanya terdiri daripada tiga bahagian, iaitu pengesanan paras lembapan tanah, pengepaman air secara automatik pada paras lembapan tanah yang rendah dan pengelogan data tahap lembapan tanah dalam peratusan ke dalam perisian Parallax Data Acquisition tool (PLX-DAQ) tambahan untuk Microsoft Excel.

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CHAPTER 1

INTRODUCTION

1.1 Background

In today's world, water scarcity is a major global issue, and agriculture, being a highly water-intensive activity. Consequently, there is a need for a system that converse water effectively. Smart Irrigation System address this by estimating and measuring the decrease in plant moisture to control irrigation, ensuring water is supplied only as necessary and minimizing wastage. However, these system require regular maintenance of their sensors to function properly. An Smart Automatic plant irrigation system focuses on watering plants consistently without the need for human supervision, utilizing a moisture sensor. Traditional irrigation methods in agriculture involve manual efforts, but automated irrigation technology can significantly reduce the need for human intervention. Agriculture often relies on rainfall, which is insufficient for the complete irrigation needs of crops. An irrigation system can supply water to fields based on soil moisture levels. While rain is crucial for irrigation, many fields primarily depend on it, necessitating additional water supply. In conventional systems, farmers must carefully manage water supply according to crops types, as insufficient watering can damage plants. To ensure the appropriate amount of water for different regions, prevent water overflow in sloped areas, and considering the farmer's needs, an efficient irrigation system is essential for proper irrigation.

An innovative agricultural system called a Smart Water Irrigation System (SWIS), uses Arduino as microcontroller for the system integration. It is intended to optimize water usage in irrigation processes through automated control and real-time monitoring.

With the help usage in irrigation processes through automated control and real-time monitoring. With the help of this system, soil moisture sensors and Arduino microcontrollers are integrated to provide accurate soil moisture level assessment and automated irrigation depending on preset criteria.

The Arduino-based Smart Water Irrigation System (SWIS) is a state-of-the-art method for maximizing water use in farming. Smart Water Irrigation System (SWIS) provides farmers with the ability to increase agricultural yields, save water resources, and advance sustainable farming methods by utilizing real-time data and automation.

1.2 Addressing Global Smart Water Irrigation System

An automated water planning system utilizing an Arduino is a smart development that reduces the need for human labor because we live in a time of smart technology, and everyone wants to be automated to reduce their workload. This was especially helpful in the agricultural industry, a farmer no longer had to constantly monitor whether their crops were being watered. Farmers in wealthy nations utilize automatic irrigation to effectively irrigate their fields. In this method, water is fed to the plant root drop by drop, which saves a significant amount of water and effectively water plants. In India, farmers typically irrigate their respective farm areas manually. This procedure uses water, and crops may not receive water at the proper location, which lowers the crop output. Plants that do not get enough water may become dry or lose freshness. If we have an automatic irrigation planting system that waters the plants just when they need it, we can fix this problem.

Using the Arduino IDE, this study was conducted on the Arduino platform. It is made up of a soil moisture sensor that measures the percentage of moisture or humidity in the soil. The moisture sensor can measure humidity in the range of 0(low) to 1023 (high). Thus, farmers will be able to determine how much moisture is in the soil and how much water the soil needs using this moisture sensor.

Therefore, to automate the process, the Arduino system uses a moisture sensor embedded in the soil to measure its moisture content. When the moisture content fell below a certain threshold, the motor was turned ON. The mechanism turns off the pump when the moisture level exceeds a predetermined limit.

1.3 Problem Statement

A major concern worldwide is that water scarcity is worsened by population, expansion, climate change, and ineffective farming methods. Approximately 70% of the freshwater used worldwide is used for agriculture, however, ineffective irrigation practices waste a large amount of this water. Conventional irrigation systems frequently cannot adapt to the actual moisture requirements of the soil, which can result in either over-irrigation or under-irrigation. This damages crop production and soil health in addition to wasting water.

The advantage of this program is that it detects the moisture level of the soil and provides water to the plant immediately, in accordance with the fast life of today’s people. It is true that there are people who enjoy planting but do not have the time or dedication to care for the plants. Therefore, this invention can make people’s lives easier and deal with their laziness in watering plants, especially in summer or summer. Moreover, this system will also benefit travelers. Before leaving the house, they can install panels that will keep the plants healthy and vibrant. After all, human participation in planting can more or less help mitigate the effects of the park and reduce the ambient temperature.

An effective way to deal with the shortcomings of conventional irrigation techniques is to create a smart water irrigation system based on soil moisture sensors and Arduino technology. This technology can help to preserve water, increase crop yields, and support sustainable agriculture by offering accurate and automated water management. Even small-scale, resource-constrained farmers can profit from this technology owing to its emphasis on affordability and usability, which supports larger initiatives to address the world's water crisis.

1.4 Project Objective

Specifically, the objectives are as follows;

a) To develop and utilize plants based on soil moisture levels detected by using sensor.

b) To develop it detects the moisture level of the soil and provides water to the plants immediately.

c) To analyze the moisture effect and humidity feature contributed by plants.

1.5 Scope of Project

The scope of this project is limited to the following items so that the project could be focused to achieve the stated objectives. In orders to achieve that stated objectives, the work scopes are listed as below;

I. The Smart Water Irrigation System based on Soil Moisture Sensor by using Arduino is designed and created by using Fritzing Software.

II. The SWIS is developed on the Arduino board with the soil moisture sensor connected. The soil moisture sensor is the programmed using C and C++ assembly language to detect the soil moisture level and control the water flow to the plants.

III. Obtain the results of the SWIS from the project develop.

This project used soil moisture and Arduino technology to construct a Smart Water Irrigation System that addresses important concerns in agriculture linked to water scarcity and wasteful irrigation practices. A sensor used in this system is a soil moisture sensor to measure the percentage of soil. The project encourages sustainable farming practices and provides a workable answer to farmers worldwide, especially those in resource-constrained areas, by optimizing water consumption and increasing crop yields. The effective execution and expansion of this initiative can substantially contribute to worldwide endeavors aimed at preserving water resources.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This part presents a study, review, and discussion of existing research on Smart Irrigation System, including a literature review. The rationale for selecting this particular project over others was also provided. Additionally, this part outlines the hardware and software utilized in the project, drawing from multiple journal sources. This part contains explanations about the research conducted.

One of the most important resources on Earth is water, which is needed to support agricultural practices that feed the world's population as well as life itself. However, effective water management has emerged as a crucial concern in light of the rising demand for food production and the escalating effects of climate change. Given the paucity of water, traditional irrigation techniques are unsustainable and can waste large amounts of water. As a result, smart irrigation systems have been developed and implemented, utilizing contemporary technology to maximize the use of water in agricultural processes

An encouraging approach to agriculture's sustainable water management is the use of a Smart Irrigation System. Water shortage and food security are major issues that these systems can assist in addressing by optimizing water utilization through the use of contemporary technologies. It will be essential to carry out more research and development in this area to get beyond current obstacles and improve the effectiveness and usability of smart irrigation solutions.

2.2 Background/Overview of Smart Irrigation System

The artificial use of water on the soil by various techniques like pumps, tubes, and sprays is known as irrigation. The requirement for irrigation typically arises in areas with erratic rainfall, during dry spells, or in regions with regular dehydration. There are far too many various types of irrigation systems available, each tailored to the specific soil conditions. Numerous sources of water can be utilized for irrigation, including surface water from lakes and rivers, subsurface water from springs or wells, and treated wastewater or desalinated seawater, among others. Therefore, by reducing the risk of disease, farmers must preserve and safeguard their agricultural water sources. Users of irrigation water must exercise caution while extracting groundwater to avoid depleting it faster than it is replenished. The classic irrigation methodology is one of two approaches used in modern irrigation systems. Sprinkler, drip, and surface irrigation are examples of traditional irrigation techniques.[2]

Water management is crucial in areas where water is scarce. Because it uses a lot of water, agriculture is also affected. In light of the likely effects of global warming, research is being done on water adaptation strategies to ensure that water is available for food production and consumption. Consequently, there has been an increasing number of research over time that have aimed to reduce the amount of water required for irrigation. Unfortunately, the cost of the sensors available for agricultural irrigation systems renders this device unaffordable for small-scale farmers. However, businesses are making inexpensive sensing devices that might be connected to nodes to create irrigation control and agricultural monitoring systems at a reasonable cost.

Irrigation system’s primary goals are to maximize efficiency and minimize the need for labor and materials. The kind and design of irrigation systems determine which management strategies have the greatest impact. How far an irrigation system succeeds is determined by several well-known issues, including knowing when to irrigate the soil, how much water is appropriate, and whether or not efficiency may be increased. There are a lot of factors to consider when choosing an irrigation system. Such as the sort of crop, the farmer's location, and the season. In general, each of these elements needs to take into account the system's compatibility with the farm's finest services, the topography and soil characteristics, crop specifications, economic viability, and some societal restraints.

2.2.1 Definitions and Importance of Smart Irrigation System

The most straightforward way to define smart irrigation is to assume that it has a smart irrigation controller. These sensors take measurements of the soil's moisture content or the local temperature, and they use that information along with other inputs from the user to modify the watering schedule. Thus, the primary characteristic of these systems is their ability to have variable watering or sprinkling schedules. With the help of smart irrigation, huge farms can precisely manage their water requirements, thus saving money and water.

It is past time for our world to go past traditional irrigation. Just put, physically watering gardens and crops is a waste of time. Time-based irrigation systems are also unable to account for variations in soil moisture levels caused by changes in the weather.

Smart irrigation technologies are now our only hope for overcoming this and improving irrigation. An irrigation system that defines its watering procedures based on soil or weather conditions is known as smart irrigation. In other words, water is conserved and crop or plant development is maximized when irrigation is tailored to the specific region being watered.

2.2.2 Historical Development of Smart Irrigation System

The development of intelligent irrigation systems is an intriguing path that combines developments in environmental management, technology, and agriculture.[16] In traditional irrigation, water is distributed to the fields from naturally existing water catchment points (such as springs, streams, and glaciers) using gravity and manually constructed ditches and channels. The start or conclusion of the watering season is frequently marked by get-togethers and celebrations, and times to physically divert the water. The implementation of traditional irrigation methods necessitates a deep comprehension of the surrounding environment, water movement, and meteorological patterns.[4] Additionally, strong collaboration is required between water distribution stakeholders, such as landowners and farmers, and those managing the upkeep of the actual infrastructure, like water cooperatives and local government agencies. [16]

The most traditional irrigation techniques are those that have been more economical and effective than others that are more recent. Even now, some of these irrigation techniques are still used.[3]

The traditional methods of irrigation include the following [3]:

- Check Basin Method
- Furrow Irrigation Method
- Strip Irrigation Method
- Basin Irrigation Method

2.2.3 Benefits of Smart Irrigation

An enhanced irrigation system known as "smart irrigation" makes use of data and technology to optimize water use and enhance plant health. It uses automation, sensors, and meteorological data to provide water exactly to plants according to their needs and the surrounding conditions. To save money and promote sustainability, smart irrigation avoids overwatering and conserves water resources. Users can conveniently and accurately operate their irrigation systems with its remote control and monitoring features. Smart irrigation ensures effective watering for maximum plant development and little environmental impact through customization choices and weather data integration.

Smart irrigation systems have many advantages over traditional irrigation methods. The main benefits of smart irrigation system are:

a) Water Conservation

Smart irrigation systems employ cutting-edge technologies including soil moisture sensors, meteorological information, and evapotranspiration modeling to precisely ascertain the hydration requirement of plants. This leads to huge water savings by preventing overwatering and ensuring plants receive the proper amount of water.

b) Cost Savings

Through water use optimization, smart irrigation systems lower water and electricity costs. Since water is a valuable resource, cutting waste lowers expenses for businesses, farmers, and individuals. Intelligent irrigation systems can be configured to capitalize on reduced tariffs times during peak hours in nations with higher peak hours tariff, hence providing significant cost savings for the end user.

c) **Improved Plant Health**

With the help of smart irrigation systems, plants can get the water they need. As a result, there is less chance of under-overwatering, which can cause plant stress, disease, and lower yields. It also guarantees that the plants receive enough moisture and encourages better growth.

d) **Increases Work Efficiency**

The watering procedure is automated by the smart irrigation system, doing away with the necessity for human oversight and modification. Farmers will save time and effort once the system is configured and able to function on its own. Farmers are not bound to the field but can utilize their time for other productive works.

e) **Integration with weather data**

Weather-related schedule adjustments depending on temperature, humidity, rainfall, and other environmental parameters can be made by smart irrigation systems by integrating real-time weather data. This optimizes water use, guarantees that irrigation is weather-appropriate, and prevents needless watering during rainy spells.

Smart irrigation systems are a noteworthy development in the field of water management technology, providing an array of benefits from reduced water usage and expenses to enhanced plant well-being and ecological durability. These systems, which address the issues of water shortages and climate change, will become even more crucial to effective and sustainable agricultural and landscape management techniques as technology advances.

2.3 Moisture Measurement Technique

A sensor is a device designed to sense, detect, and respond to a variety of signals from the environment. Inputs typically include environmental factors such as light, speed, temperature, humidity, and pressure. The output produced by the sensor is a signal that can be displayed in a readable format at the sensor location or transmitted electronically over a network for further analysis or processing. In this project, a moisture sensor is used to measure soil moisture.[17]

2.3.1 Types of sensors

Sensor	Function
Soil Moisture Sensor	To measure or estimate the amount of water in the soil. These sensors can be stationary or portable such as handled probes.
Humidity Sensor	A device known as a humidity sensor detects, measures, and reports the air's relative humidity (RH) or the amount of water vapor in either pure gas or a gas mixture (air).

Water Depth Detector	Depth can assist in calculating flow volumes, which in turn helps translate results for pollution concentrations into loads on the environment. Moreover, it can be used to set up storm events and start automated samplers.
Soil Nutrient Sensor	To measure soil moisture, electrical conductivity, temperature, and pH elements at the same time. It can be utilized for affordable, long-term, and stable soil condition measurement in a defined region.
Rain and Freeze Sensors	To measure tool that can identify both rain and freezing temperatures. This gadget is a great addition to any irrigation system because it is made to stop irrigation when certain weather conditions occur.

Table 1: Type of sensor

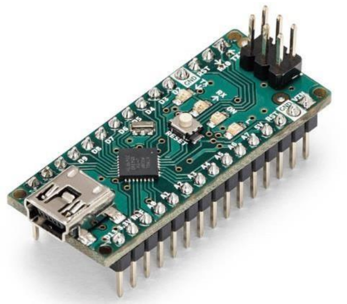
2.4 Arduino Microcontroller

Arduino is one of the basic tools used in Smart Irrigation System. Arduino is an open-source electronic platform that combines easy-to-use hardware and software designed to make it easy to create interactive projects. Arduino Uno board was chosen for this project. It acts as an environmentally aware hardware device that receives input from various sensors and influences the environment controlling motors, lighting, and other function. This is achieve by connecting the system to various expansion cards and other devices. The board has hardware-like digital input/outputs and has internet communications, including a USB port for transferring software to a laptop or personal computer. Arduino software, also known as Arduino Integrated Development Environment (IDE), is used to write and edit programs in C and C++ languages. [19]

2.4.1 Type of Arduino Microcontroller

There exist various varieties of Arduino boards, with distinct functions and features tailored for varied uses. The Arduino Uno, Arduino Nano, Arduino Mega, Arduino Leonardo, and other models are among the most widely used Arduino boards.[12]

Type	Functions
Arduino Uno 	The Arduino UNO is an open-source, programmable microcontroller board that is inexpensive, versatile, and easy to use. It may be used in a wide range of electronic projects. This board can control relays, LEDs, and motors as an output and can interact with other Arduino boards, Arduino Shields, and Raspberry Pi boards.
Arduino Nano	The Nano board can establish communication with computers and another controller. Pin0 (Rx) and Pin1 (Tx), which are digital pins used for data

	transmission and reception, respectively, carry out serial communication.
Arduino Leonardo 	The ATmega32u4 on the Leonardo is different from all previous boards in that it features integrated USB communication, which means that a secondary CPU is not required. This enables the Leonardo to function as a virtual (CDC) serial/ COM in addition to a mouse and keyboard on a connected computer.
Arduino Pro mini 	The semi-permanent placement of the Arduino Pro Mini in objects or exhibitions is its intended use. Since the board does not include pre-mounted headers, wires can be soldered directly to the board or a variety of connectors can be used. The Arduino Mini is compatible with the pin layout.
Arduino Mega2560	The ATmega2560 microprocessor serves as the foundation for the Arduino Mega 2560 development board. This board has 16 analog pins and 54 digital I/O pins, of

	which 15 are used for PWM output. As a result, it is a fantastic choice for projects that need more GPl0 pins and memory space.

Table 2: Type of Arduino microcontroller

2.4.2 Application of Arduino in Embedded System

Embedded systems use Arduino boards extensively because of their adaptability, simplicity of usage, and rich ecosystem of libraries and community support. In embedded systems, Arduino is used in the following noteworthy applications:

a) **Home Automation**

Smart Lighting: Motion sensors and light-dependent resistors (LDRs) can be used to control lighting depending on occupancy or time of day.

Security Systems: Put alarms, door sensors into practice. To identify intrusions and send out alerts or messages, Arduino can interface with a variety of sensors.

b) **Environmental Monitoring**

Soil Moisture Sensor: For agricultural purposes and smart irrigation systems, keep an eye on the conditions of the soil.

Air Quality Monitor: When in an industrial or urban environment, use gas sensors to check the quality of the air and identify pollutants.

c) **Internet of Things (IoT)**

Smart Appliances: Connect your home’s appliances to add automation and remote control capabilities.

Connected Devices: Use Wi-Fi, Bluetooth, or other communication modules to connect devices to the internet for remote monitoring and control.

2.5 Comparison of other projects using other types of Arduino and Sensors in Smart Irrigation Systems.

The development of a Smart water irrigation system based on soil moisture sensors by using Arduino has garnered substantial attention in the past few years. Smart irrigation systems can be built using various types of Arduino boards, each offering different features and capabilities that may suit different project requirements.

Previous Research on the Development of a Smart Water Irrigation System based on soil moisture sensors by using Arduino.

No	Tools/Method Used	Author	Advantage(s)	Disadvantage(s)	Commendation/Suggestion
1	• Arduino Uno • ATMEGA328 Microcontroller • Relay • Pipe • Connecting Leads • Relay	Singh, S., Upreti, S., Sarkar, P. 2015	The system can save time you don't have to water the plant daily basis it can water the plant by itself.	The system needs electricity continuously it can't run without electricity. The soil moisture sensor gets rusted after some time.	Position soil moisture sensors in strategic locations across the garden to obtain an average reading and prevent over or under-watering of particular sections.
2	• Arduino • Temperature and Humidity Sensor • Water Pump	Rajalakshmi, 2018	Used Arduino as the microcontroller that is used to control the system operation automatically.	No value of soil moisture and light intensity is displayed to the user.	This system should show the value of moisture and light intensity to the user.

	• Light Bulb • Soil Moisture Sensor • Light Sensor				
3	• Soil Moisture Sensor • Relay • LCD Display • ATMEGA Microcontroller	Mr, Sundar Ganesh C S, 2013	Use to build up a microcontroller-based framework to water the plant naturally.	Cost of purchasing, installing, and maintaining the equipment.	The project should have a backup system that manually switches on and off the motor.

4	• Soil Moisture Sensor • Wireless Transmission • Raspberry Pi • Humidity Sensor • Soil Nutrient Sensor • Water Depth Detector	Anamika Mitra, Pooja, Gaurav Saini, 2019	The suggested system uses an Arduino as its central component and it is designed to water the plants automatically.	Enhanced upkeep of the equipment and channels to guarantee proper operation.	This system should operate automatically and does not require clicking on the web application to turn on the pump and sprinkler.
5	• Arduino Uno Rev3 • Soil Moisture Sensor YL-69	A.Hassan, W.M.Shah N.Harum, N.Bahaman &	Low cost compared to proprietary systems, open-source	Environmental elements such as severe temperatures, moisture, and dust can cause components to break down.	This project should select dependable soil moisture sensors (such as capacitive sensors) and make sure their calibration is correct.

	• LCD Display • Relay Module • DC Water Pump	F.Mansaourkiaie, 2019	microcontrollers are typically less expensive.		Take into account adding more light, humidity, and temperature sensors to improve the system's ability to make decisions.
6	• Arduino Uno • DHT11 Temperature and Humidity Sensor • Connector Wire • Bread Board, Laptop • Soil Moisture	Anitha et al, 2018	Water in the pot can be detected using a water sensor. Users are able to see data log in the IoT cloud.	On an IoT website, the user does not see any soil value presented.	A manual backup system for turning on the water pump should be included in the project.

7	• Arduino Uno • GSM module • Water Pump • Relay 12V • Soil moisture sensor • Power Supply	Abbay Sharma, Harpreet Kaur Channi, 2021	Using these methods is that they reduce human interference while maintaining the necessary watering.	Environmental elements including heat, moisture, and dust may have an impact on components.	These elements should be taken into account when deciding whether to utilize Arduino for a smart irrigation
8	• Arduino Uno • FC-28 Soil Moisture Sensor • LCD Display • Buzzer • LED • Relay • Water Pump	Mon Arjay F. Malbog et al, 2020	Irrigation can be done more precisely with fuzzy logic since it can tolerate unpredictability	The soil moisture sensor's dependability and accuracy have a major impact on the system's accuracy	The project should have backup system that manually switched on the motor.

9	• Soil moisture • Water flow temperature • ESP8266 Wifi Module • Router	Singh and Saikia, 2017	Use a water flow sensor to measure the requirement of water for every particular crop.	Users need to control the water pump and sprinkler manually by clicking on the web application of the system.	This system should operate automatically and does not require clicking on the web application to turn on the pump, and sprinkler.

Table 3: Comparison for Previous Research

2.5.1 Explanation for Comparison Previous Research

1. **Automatic Plant Watering System using Arduino Uno (Singh,S,Upreti,S., Sarkar,P, 2015)**

   The main purpose of this automatic plant watering system is to provide automatic watering using Arduino Uno. It solves the problem of monitoring soil levels and support crop growth, reclamation of degraded land in arid areas, nature conservation and underguate rainfall conditions.[11]

2. **Plantation Soil Moisture and Temperature Monitoring System (Rajalakshmi, 2018)**

   This project improves traditional irrigation by developing a system that allows users to water their plants and control the light intensity.

3. **Efficient Automatic Plant Irrigation System using ATMEGA Microcontroller (Mr, Sundar Ganesh C S, 2013)**

   Irrigation systems are important in agriculture. Labor and water saving technologies are essential in irrigation. The main purpose of this project is to develop a microcontroller system that automatically waters plants. The system also aids water management decisions by determining the right time for irrigation. Additionally, the project aims to send text messages to the user indicating that the engine is ON and OFF.[7]

4. **Automated Smart Irrigation System (ASIS) (Anamika Mitra, Pooja, Gaurav Saini, 2019)**

   A smart city boasts of services that aim to enhance the quality of life by not only providing the basic amenities, but also the efficiency and performance of systems and processes that ensure economics, and sustainability. A smart automated system can solve it using new and smart technologies like IoT, sensors, and wireless technologies to operate from remote locations, and this is the main objective of this project.[7]

5. **Automated Irrigation System using an Open Source Microcontroller (A.Hassan, W.M.Shah N.Harum, 2019)**

   The main aim is an affordable automated irrigation system utilizing an Arduino microcontroller system is propose, one that can be applied to both a typical residential garden and a farm. The suggested system uses an Arduino as its central component and is designed to water the plants automatically when the soil moisture sensor detects a lack of water in the soil.[18]

6. **Smart Irrigation Automation System using IoT (Anitha et al, 2018)**

   The farming systems that farmers use to irrigate their traditional crops are labor-intensive and water-intensive. The new system automates irrigation, reduces water waste, and includes a soil nutrient sensor to measure soil moisture levels.[6]

7. **Designing of Smart Irrigation System using Arduino (Abbay Sharma, Harpreet Kaur Channi, 2021)**

   This “System of Automatic Irrigation” project is an automated irrigation mechanism that senses the earth’s moisture content and actives or deactivates the pumping motor. The application of suitable irrigation techniques is important in the field of agriculture. The advantage of using these methods is that they reduce human interference while maintaining the necessary watering. An Arduino board microcontroller is used in this controlled irrigation project. It is configured to receive input signals from a moisture-detecting device that indicate changes in the earth’s moisture content.[9]

8. **A Fuzzy Rule-Based Approach for Automatic Irrigation System through controlled Soil Moisture measurement. (Mon Arjay F, Malbog et al, 2020)**

The research attempts to create an irrigation water management system that regulates the amount and timing of irrigation water that is applied to the lands as well as a low-cost sensor that monitors soil moisture content as precisely as the more expensive sensors available. The FC-28 soil moisture sensor underwent 60 experiments with varying soil types to establish its validity and the results are consistent with those of other soil moisture measurement devices available in stores. This study demonstrates the effectiveness and accuracy of the soil moisture sensor-controlled automatic irrigation system.[8]

9. **Arduino-based Smart Irrigation System using Soil Moisture Sensor, Water Flow Temperature Sensor, and ESP8266. (Singh and Saikia, 2017)**

This research attempt is to present a controlled irrigation system based on Arduino that is inexpensive, and simple to operate. The system is designed to handle a variety of environmental elements, including dampness, sensors such as water flow, temperature and soil moisture to determine the temperature and amount of water needed by the crops. An interactive website that displays the real-time values and standard values of many factors required by a crop may be accessed by connecting the Arduino, which gathers and receives data.[13]

2.6 Summary

This journal reviews Smart Irrigation Systems and monitoring techniques that increase irrigation effectiveness in smart agriculture. The study has been structured around irrigation scheduling and control monitoring strategies. Additionally, a conversation regarding the opportunities for future research based on study gaps has been scheduled. It is stated in this regard that open fields should be researched in conjunction with a discrete forecasting control system, utilizing a combination of soil-based, weather-based, and plants-based monitoring techniques. Research on environmentally controlled agriculture does not address the uncertainties that need to be explored in open-area agricultural irrigation systems. Future research will therefore concentrate on the creation of process dynamics approaches for irrigation systems and the effects of sophisticated monitoring and regulating strategies on irrigation production in open-field agriculture.

CHAPTER 3

METHODOLOGY

Methodology refers to the theoretical analysis of methods related to a particular method of study or the evaluation of principles and principles related to a branch of science. They typically include concepts such as paradigms, representation models, classifications, and holistic or qualitative methods. This section provides a detailed description of the procedures used efficiency. This section covers design, architecture, software development processes and system architecture.

3.1 Introduction

This section explains the project process from the first stage to the final stage, focusing on the Smart Water Irrigation System based on Soil Moisture Sensor by using Arduino. Both hardware and software tools were used to complete this project. Various methods were applied to achieve the project's objectives. The project is divided into three main parts which is project planning, hardware and software. Additionally, diagrams and schematic diagrams were used in this section to assist the interpretation process.

3.2 Project Methodology

In this project, the process includes stages that are completed from start to finish. These 3 main stages are planning, implementation and analysis.

Stage 1: Planning

- This stage is involves conducting a literature review and project planning.

1. Conduct a complete literature review on Arduino-based soil moisture sensor systems, focusing on hardware and software aspects for better understanding.
2. Then, prepare a project development plan and solution that covers all stages from initial idea to successful completion of the project.

Stage 2: Implementation

- This section provides a detailed explanation of the development of the project, including hardware and software.
    1. This project is divided into two main sections, hardware and software.
    2. Programming the microcontroller using languages such as C or C++ via the Arduino IDE software.

Stage 3: Analysis

- This phase focuses on testing and troubleshooting the project.
    1. Test and analyze results.
    2. Perform troubleshooting steps to resolve any errors or problems encountered.

3.2.1 Project Planning

Project planning begins with the idea, selection and title of the projects as the first step. Students used to variety of methods, including the internet and real-life observations, to come up with a project idea. Some aspects of the projects are selected for students, such as community needs, industry, or literature review.

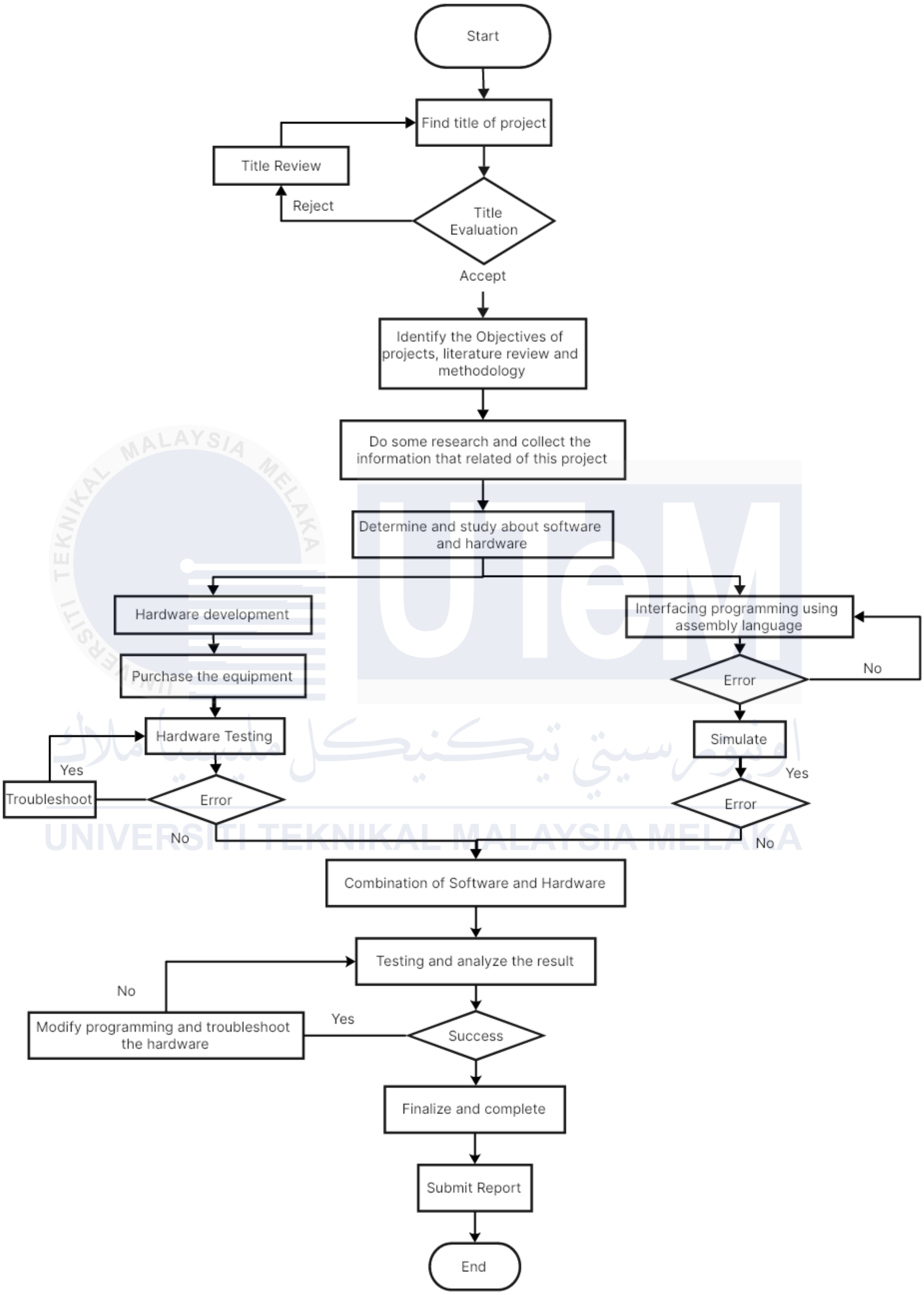


Figure 3.1 Flowchart of project planning

Based on Figure 3.1, the project planning flow chart shows the development of this project on Smart Water Irrigation System. This project is started by finding and deciding a final year project title. This project title is then reviewed by supervisor for suggestion and approval. The project title searched with the intention that this project which based on Arduino technology will bring benefit to community. After the title is decided, the project proposal is completed and the literature review is relevant to Smart Water Irrigation System together with fertigation are done. By referring to the literature information from survey, the project is planned on which hardware and software can be used to make the smart water irrigation system function well at the end of the project. In this case, the hardware requirement and software requirement is analyzed. After deciding all the hardware and software, the project is started with the development of both hardware and software. The related hardware to be used in this project are needed to find and test their functionality with Arduino IDE software after combining all components on breadboard. In this project, the main hardware required is Arduino Uno and soil moisture sensor or simply known as grove. Meanwhile, the software used in this project is Arduino software that is Arduino Integrated Development Environment (IDE). Arduino IDE software uses assembly language such as C and C++ language. In order to make the system function, this smart water irrigation system will need the combination of both hardware and software whereby system will function in the aspects that the microprocessor ATmega328p on the Arduino board will act as the processor to flow the water from a bucket or a tank of water when the soil moisture sensor detect the soil moisture level is under a certain range of values. After the system is managed to function successfully, the project is finalized and considered completed. Then the report that including all the information related is submitted.

3.3 Hardware

3.3.1 System Block Diagram

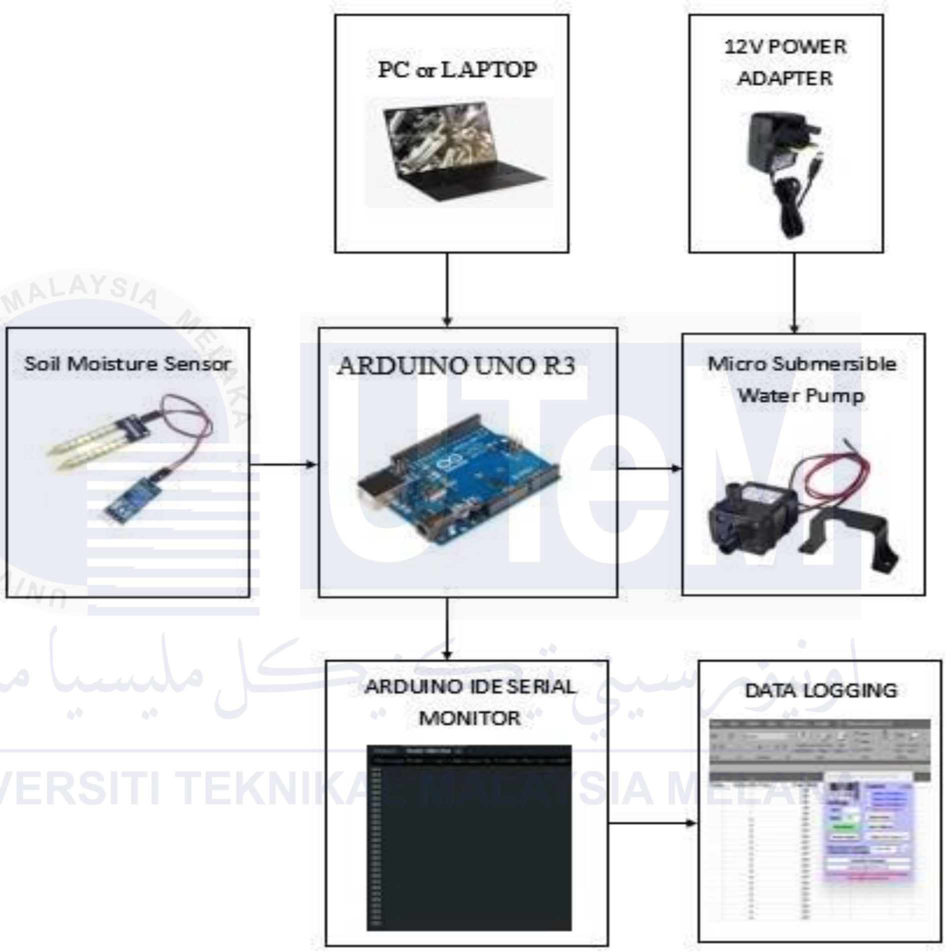


Figure 3.2 Block Diagram of the system

Figure 3.2 shows the block diagram of the Smart Water Irrigation System based on Soil Moisture Sensor by using Arduino. The project is divided into hardware and software component. The main hardware used in this project is Arduino and Soil moisture sensor, while the Arduino software is used with the sensor. First of all, the connection of the sensor is made with the Arduino board. In order for the system to work, there must be a personal computer or laptop that acts as a connection device. The Arduino board is connected to the interface and the C or C++ language compiled into the Arduino software must be installed first. Soil test are placed on the ground and are intended to determine the moisture content of the soil.

3.3.2 System Flowchart

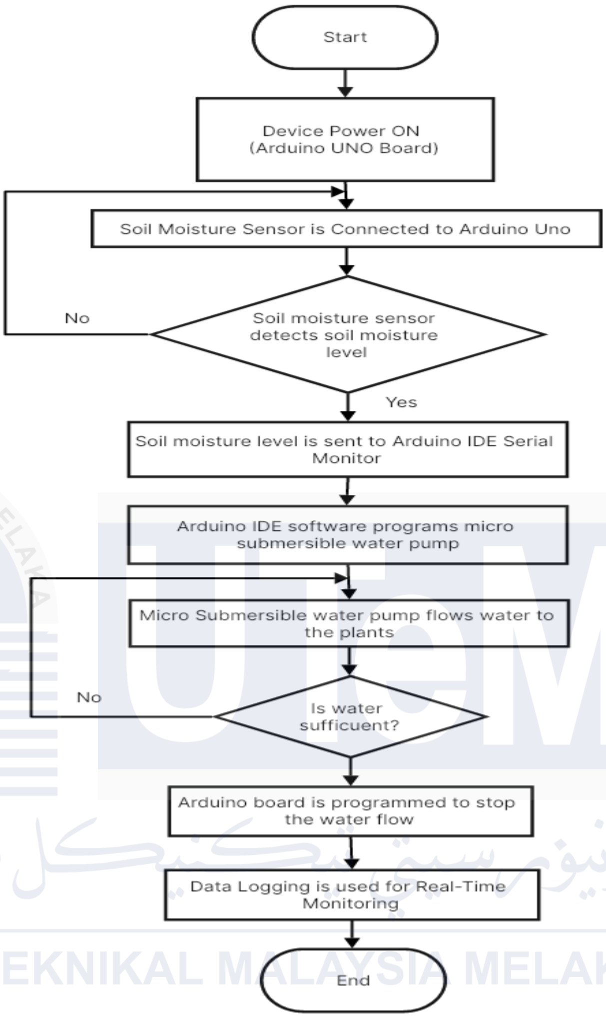


Figure 3.3 System Flowchart

The project flowchart according to Figure 3.3 shows the progress of this project on Smart Water Irrigation System based. The system begins with power on the Arduino Uno to connected the soil moisture sensor. First of all, the system must be power ON. After that, the soil moisture sensor can detect the soil moisture level by connecting it to Arduino board. If the soil moisture level is detected to be under certain range of values, the submersible pump will flow the water to plants. However, the micro submersible water pump will stop the water flow once the soil moisture level is sufficient. Only certain amount of water programmed with Arduino software will flow to the plants for each time.

Data logging is utilized to monitor the soil moisture level in real-time directly from Arduino IDE serial monitor into Microsoft Excel using Parallax Data Acquisition tool (PLX-DAQ) Spreadsheet.

3.3.3 Arduino Uno Board

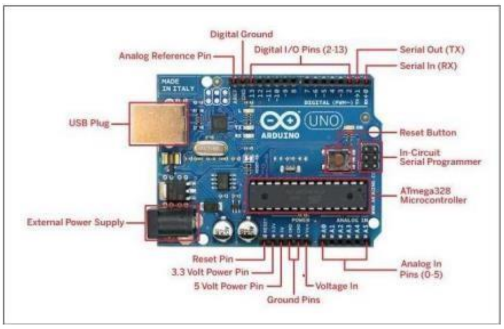
Figure 3.4 shows Arduino Uno Board an open-source microcontroller board based on the ATMEGA328P architecture is called the Arduino Uno. 14 digital input/output pins, 6 analog inputs, an ICSP header, an USB port, a power jack, a 16MHz quartz crystal, and a reset button are all present on an Arduino board. Since it is in charge of all the hardware that is connected to it, the Arduino serves as the project's key component. It can be started by connecting a personal computer (PC) to a USB port or by using it with a battery or AC to DC adapter. This Arduino board differs from other boards or devices in the common interface that allows the CPU board to be connected to the shield. In this case, the display may be another switching module. While some shields communicate via serial I^2C bus, a shield communicates with the Arduino board via a pin.

In the Arduino board, there is a microcontroller on it that functions by uploading the program to the on-chip flash memory. Arduino has the advantage of allowing a computer to be used as a programmer, making it need to not connect to an external programmer. Arduino Uno board provides 14 digital I/O pins, six of which can produce pulse-width modulated signals, and six analog inputs, which can also use six digital I/O pins. These pins are on the top of the board, using female 0.10-inch (2.5mm) headers.

Figure 3.4 Arduino Uno Board

3.3.3.1 Specification of Arduino Uno Board

Figure 3.5 shows a pin schematic for an Arduino Uno R3. It has I/O with 14 digits. 6 pins can be used as PWM outputs from these pins. There are 14 digital input/output pins, 6 analog inputs, a USB port, a quartz crystal that operates at 16 MHz, a power jack, a USB port, a resonator that operates at 16 MHz, an ICSP header, and an RST button on this board.

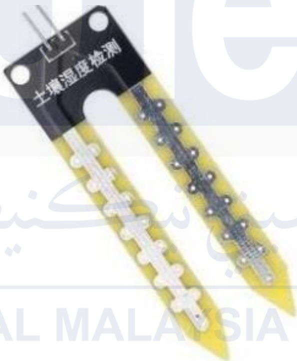


Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 Ma
DC Current for 3.3V Pin	50mA
Flash Memory	32 KB of which 0.5KB
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz
Length	68.6 mm
Weight	25g

Figure 3.5 Specification of Arduino Uno Board

3.3.4 Soil Moisture Sensor

The moisture sensor is used to measure the amount of the water in the soil or to evaluate the presence of water around the sensor by simply immersing it in the soil. When soil moisture decreases, the basic value of the sensor is displayed so that the plant can understand whether it needs water or not. This could make field crops more accessible to humans and more readily available for use in horticulture. It is also good to do research on subjects such as natural sciences, agronomy, soil science, horticulture and biology.



Item	Condition	Min	Typical	Max	Unit
Voltage	-	3.3	-	5	V
Current	-	0	-	35	mA
Output Value	Sensor in dry soil, Sensor in humid soil,Sensor in water	0, 300, 700,	-	300, 700, 950	-

Figure 3.6: Specification Soil Moisture Sensor

3.3.5 Micro Submersible Water Pump (Mini Water Pump)

Figure 3.7 shows a submersible water pump is a device that has a motor hermetically sealed in the pump body and the entire assembly is submerged in water for pumping. This submersible pump has the advantage of preventing pump cavitation. In other words, it can be used to solve problems related to the height of the pump and the water surface. Additionally, the blade pumps push the water upwards. Additionally, a submersible pump pushes water up, unlike a jet pump that has to pull water down. In comparison, submersible pumps are better than jet pumps in terms of efficiency. For this projects, a submersible water pump will be used to pump water from buckets or water tanks to the plants.

Figure 3.7 Micro submersible water pump

3.3.6 One-Channel Relay Module

Figure 3.8 shows a relay is an electromechanical device that opens or closes a switch's contact using an electric current. The single-channel relay module is much more than just a simple relay, it includes parts that facilitate connection and switching as well as indicators that indicate if the module is powered and whether the relay is operational. In other words, it is an automatic switch that allows low-frequency signals to create a high- frequency circuit. The real advantages lie in low movement inertia, long-term reliability, small size, and stability. It is widely used in automatic technology, energy- saving equipment and electronic and electronic equipment.

Generally, a relay contains an induction unit that can signal input variables such as current, speed, light, resistance, speed, voltage, temperature, frequency, and power. It also includes an active (output) module that can enable or disable connected controlled channels. There is intermediate section between the input part and the output part, which is used to connect and disconnect the input and create the output. When the specified input value (temperature, current, voltage, etc) exceeds the critical value, the control relay circuit is energized or de-energized.

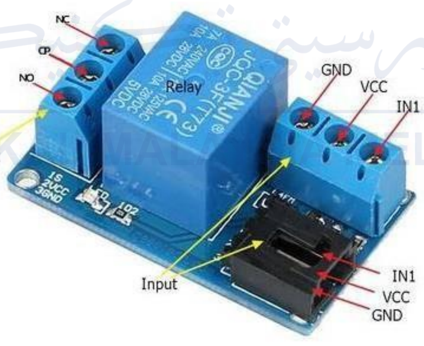


Figure 3.8 One Channel Relay-module

3.4 Software

3.4.1 Arduino IDE software

Figure 3.9 shows the software used for this project on Arduino is the Arduino Integrated Development Environment (IDE). This software includes features like syntax highlighting, automatic identification, and curly bracket matching in the code editor. Therefore, it can compile and deploy programs just by clicking on the clipboard. C and C++ languages are used for this. With the contributions and outputs given, the program will now become much simpler. Once the programmer creates the programming language, the IDE for Arduino will convert the language into a text file and hexadecimal code so that the microcontroller can read the programming language.

Figure 3.9 Arduino IDE

3.5 Data Logging

Data logging is the gathering of information over a timeframe and is something frequently utilized in scientific experiments. Data logging systems normally use a sensor for process-monitoring that connected to a personal computer or laptop. Most data logging should be possible consequently under a computer control.

3.5.1 The Data Logging Process

Sensors have an essential part in data logging process since all physical properties can be measured using sensors like light, sound, heat, acidity, pressure and humidity. The sensors can send the signal to an interface box that is connected to a laptop. The interface box converts analogue signals to digital signals that the PC can get it. The computer controlling the process will take readings at constant time intervals. This time interval for data logging period is the total length of time over which readings at constant time intervals. This time interval for data logging refers to the time between readings. The Data Logging period is the total length of time over which readings are taken. Then the readings are tabulated in tables and can be shown in graphs or pass to an application, such as spreadsheet for later analysis. Figure 3.10 shows the taking an example for data logging process, an experiment is taken out to determine the rate at which water cools down from boiling points as shown below:

1. A temperature sensor is put in the liquid.
2. The sensor is connected to an interface box that is connected to the computer.
3. The data logging software is programmed to take the readings every 30 seconds (time intervals) for 25 minutes (logging period).

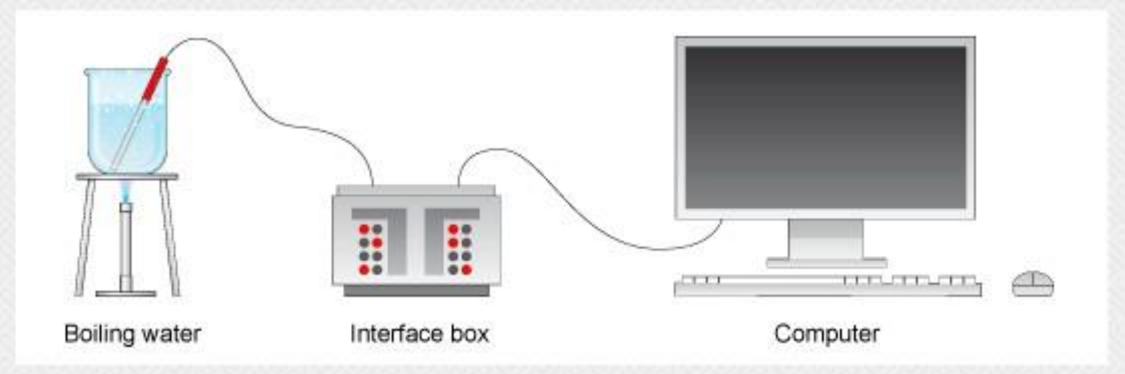


Figure 3.10 An Experiment to record the water cooling

3.5.2 Parallax Data Acquisition tool (PLX-DAQ)

PLX-DAQ is a Parallax Microcontroller Data Acquisition add-on tool for Microsoft Excel. Any microcontroller linked to sensors and the serial port of personal computer or laptop can send data to Excel directly. Below are the features of PLX-DAQ:

- Mark data with real-time (hh:mm:ss) or second since reset.
- Plot or graph data as it arrives in real-time using Microsoft Excel.
- Read/Write any cell on a Worksheet.
- Read/Set any of the 4 checkboxes on control the interface.
- Baud rates up to 128K.
- Support Com 1-15.

The serial port speed required by PLX-DAQ is particular, because it derives from Parallax world. In any case the rate is from 9600 bit/sec to 128.000 bit/sec works fine in the Arduino!!

The main commands are:

- **LABEL** used to define the column headings.

  The command format is: Serial.println("LABEL,INT_COLUMN");

- **DATE, TIME** that allows the serial port to send data to Excel.

The first field is always TIME, then the fields of interest (val).

The command format is: Serial.print(“DATE, TIME,”); Serial.println (val)

- **ROW, SET, k**, allows one to define the next line to write.

  It is useful to plot and data and then go back to first row and cycle. For example, one can plot 1000 data on the chart and then start again from the first position, in order to avoid a graph too large. The command format is: Serial.println (ROW, SET, 2) put the cursor in the second line next step.

CHAPTER 4

RESULTS AND DISCUSSION

4.0 INTRODUCTION

The previous chapter is more to discussion on methodology and flow of the implementation of Smart Water Irrigation System based on Soil Moisture sensor by using Arduino. For this Chapter 4, the result and analysis that comprised of implementation, simulation and testing together with the coding and functionality of the project will be included. In these circumstances, collected data will be tabulated as result part and these data will be analyzed. In addition, there will be also the design of the Smart Water Irrigation System using hardware as well as the analysis of the soil moisture sensor and the submersible pump. Apart from that, this chapter also discussed about the circuit description, the sensors functionality as well as the importance and impact of the project. In addition, the data logging will be applied to send data directly from Arduino to Excel and plot the graph data as it arrives in real-time. The purpose of doing this chapter is to make the project implementable as desired. At the end of this chapter, analysis for this project is very useful to improve the project. Then, the next chapter will be recommendation and conclusion for the entire project.

4.1 Smart Water Irrigation System based on Soil Moisture by using Arduino

This Smart Water Irrigation System based on Soil Moisture Sensor by using Arduino is created with the combination of software and hardware. This project mainly consists of three parts, which is detection of soil moisture level, auto pumping of water upon the low soil moisture level and the data logging of soil moisture level in percentage into Parallax Data Acquisition tool (PLX-DAQ) software add in for Microsoft Excel. For the first part, soil moisture sensor is used to determine the soil moisture level. Whereas for the second part, combination of both hardware and software are applied whereby the submersible pump is connected togethers with relay to control on and off upon the soil moisture level. In this case, C or C++ programming language is applied in Arduino IDE software to program the Arduino board for the auto water pumping purpose. Lastly, the PLX-DAQ provides simple spreadsheet Parallax microcontrollers and thus, will log the data of soil moisture level received from the Arduino into the columns to enable the data analysis, experimental analysis of soil moisture sensor and real-time monitoring of watering system. In these circumstances, the graph data of soil moisture level can be plotted as it arrives in real-time when data logging is applied to send data directly from Arduino to Excel.

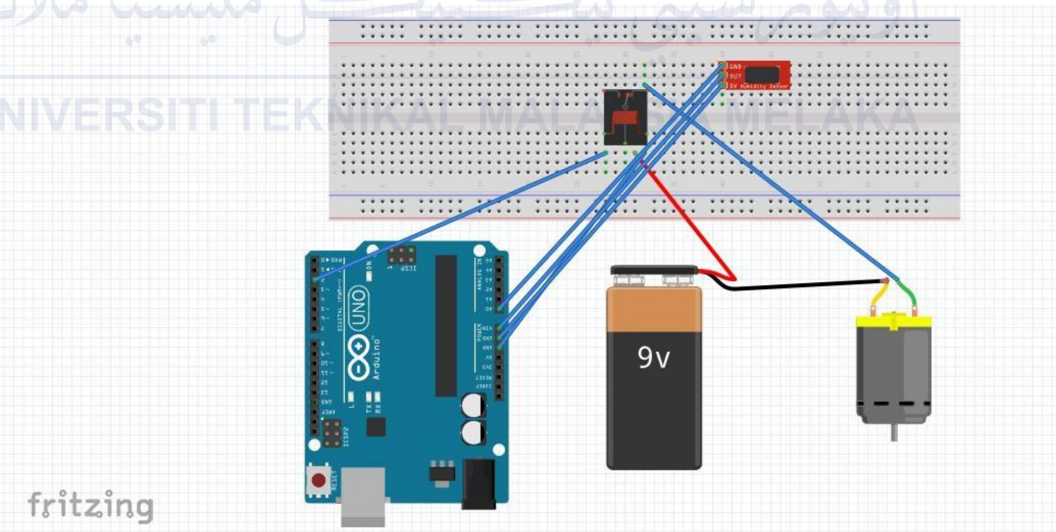


Figure 4.1 Schematic Diagram of Smart Water Irrigation System using Fritzing Software

In figure 4.1 above depicted the schematic diagram of Smart Water Irrigation System based on Soil Moisture using Fritzing Software. Due to the lacking of components required, 9V battery is used to indicate 12V DC power adapter and the motor is used to represent 12V micro submersible water pump. The 5V relay is placed on breadboard but the 5V module is used in reality. The positive edge of 12V DC power adapter is connected to COM of relay whereas the negative edge of 12V DC power supply is connected to negative edge of micro submersible water pump. The two pinout coils are connected to Arduino Uno ground pin and digital pin 2 of Arduino Uno respectively. For this project, normally open pin of 5V relay is connected to positive edge of micro submersible water pump instead of normally close pin to enable water flow until the soil in humid state.

4.1.1 Hardware Results

An Smart Water Irrigation System based on Soil Moisture Sensor by using Arduino was created. A prototype has been created by consisting of an electrical box with full circuit inside, piping system with dripping irrigation applied using transparent hose and two potted plant placed in series that share the same piping. Figure 4.2 shows the Smart Water irrigation System prototype that have been designed and constructed.

4.1.2 Connection of Arduino Uno and Soil Moisture Sensor

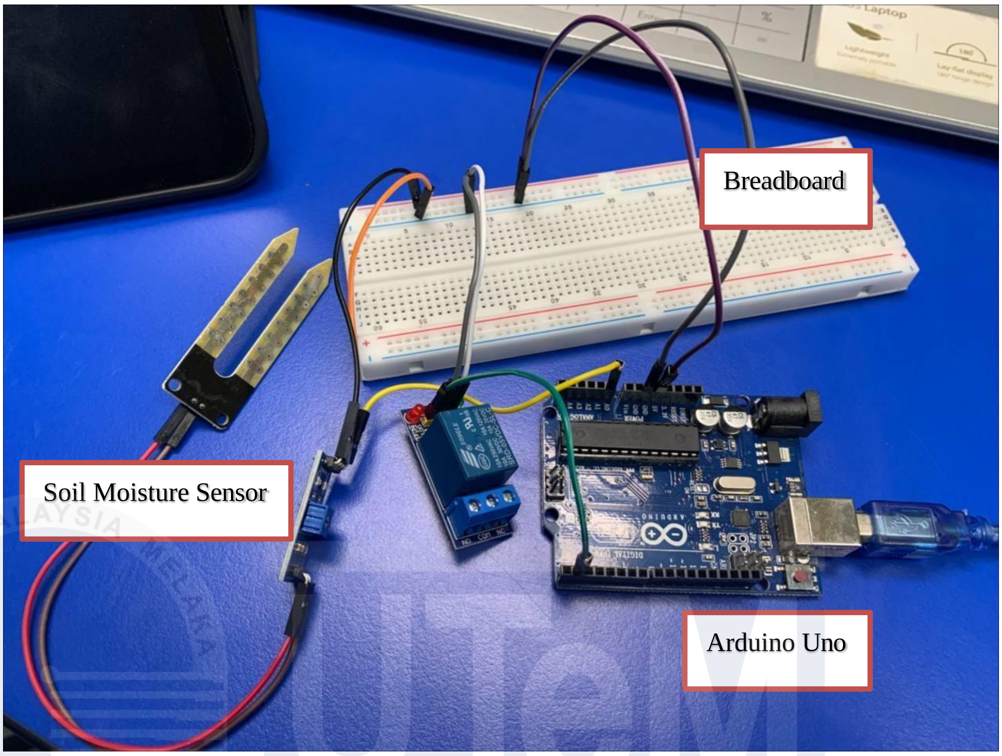


Figure 4.2 Connection of Arduino Uno and Soil Moisture Sensor

In Figure 4.2 above shows the connection of Arduino Uno and Soil Moisture Sensor. The soil moisture sensor comprises two probes to detect the resistance of soil for reading moisture level when current passes in soil. For the information, there are circuitry inside the soil moisture sensor for measuring the resistance into voltage as output. In fact, the soil moisture sensor interfaces with Arduino Uno by connecting A0, VCO+ and GND to A0, Vin and GND in Arduino Uno respectively using female to male jumper wires.

4.1.3 Connection of Arduino Uno, 12V DC Submersible Water Pump, 5V Relay Module and 12V Power Adapter.

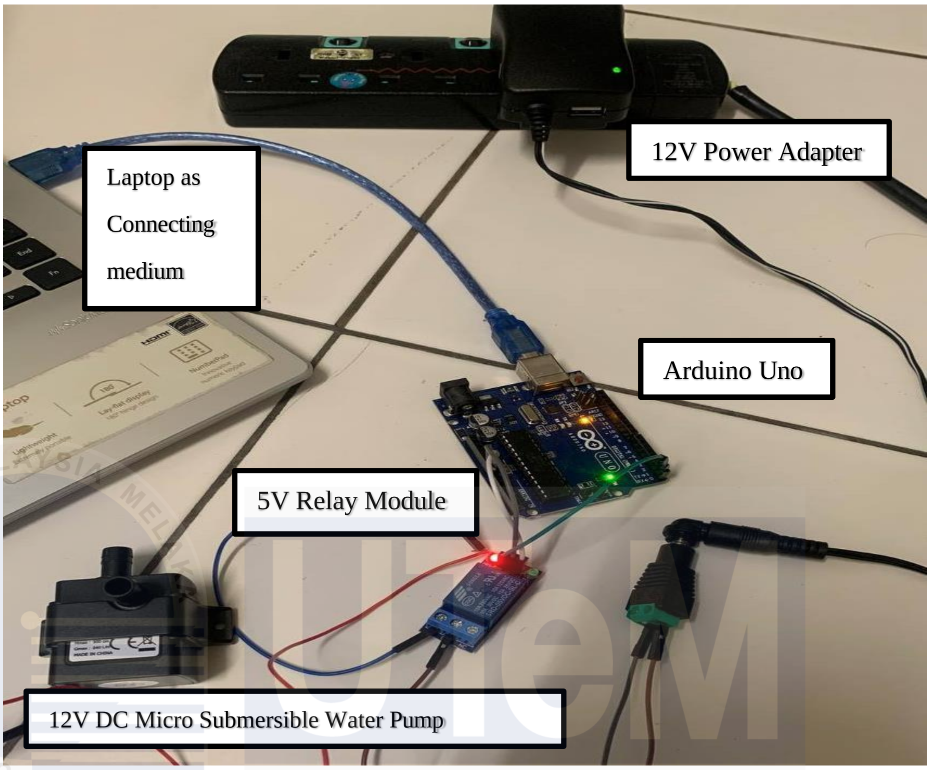


Figure 4.3 The connection of Arduino Uno, 12V DC Submersible Water Pump, 5V Relay Module and 12V Power Adapter.

In figure 4.3 above shows the connection of Arduino Uno, 12V DC Submersible Water Pump, 5V Relay Module and 12V Power Adapter. The submersible water pump can be directly connected to the power adapter, but it have to be programmed so that water flow can be controlled by turning the submersible pump ON and OFF when the soil moisture level is too low or too high. Hence, 5V relay module is chosen to conduct this desired result. The positive lead of the 12V power adapter is connected to normally open pin of 5V Relay Module to ensure the continuous water flow when soil moisture level is less than the percentage set in Arduino IDE using C/C++ programming language.

4.1.4 Smart Water Irrigation System based on Soil Moisture Sensor by using Arduino prototype.

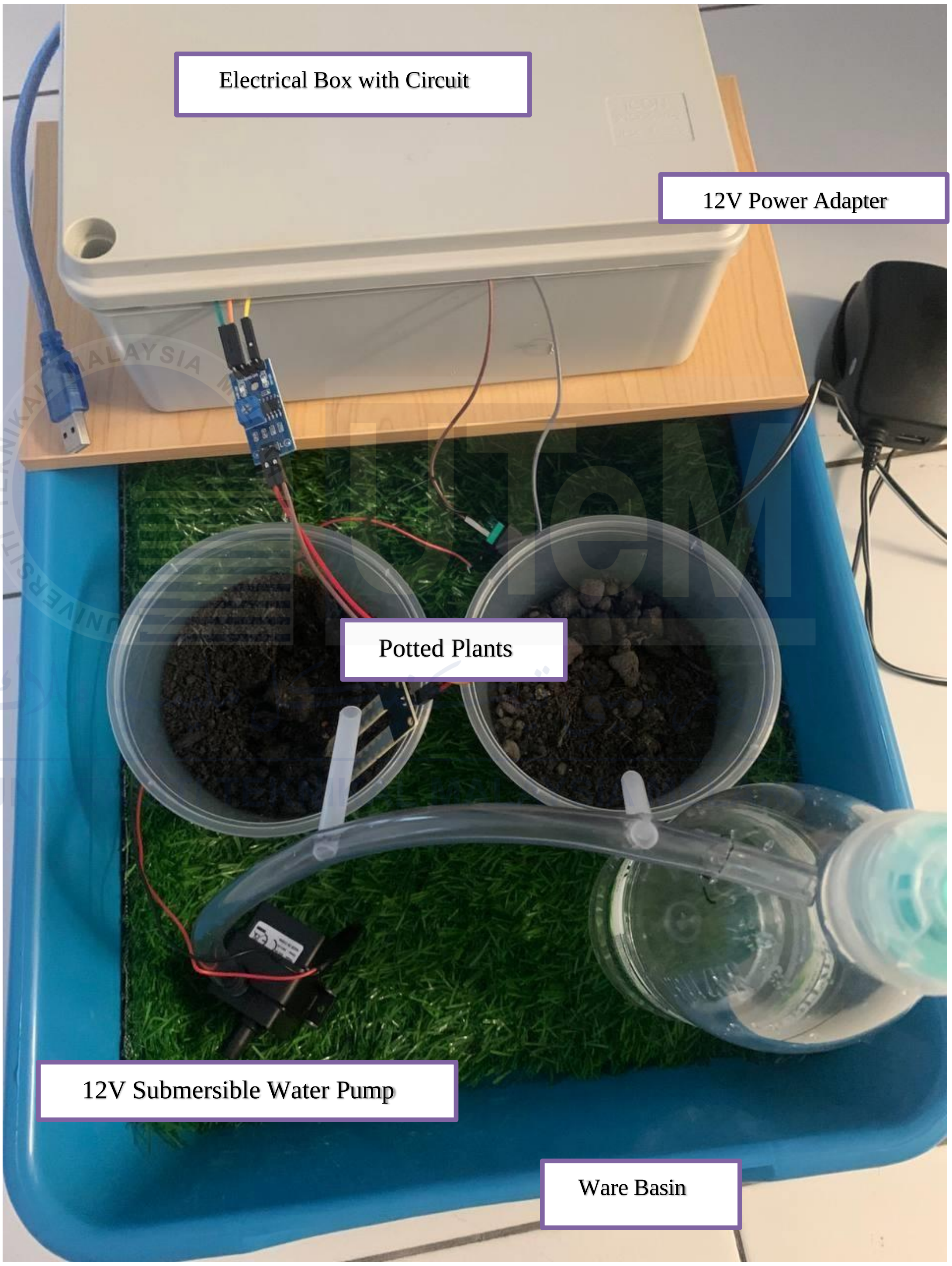


Figure 4.4 Smart Water Irrigation System prototype.

4.1.5 Full Connection of Smart Water Irrigation System based on Soil Moisture Sensor by using Arduino.

The full connection of the Smart Water Irrigation System between Arduino, soil moisture sensor, 5V relay module, 12V submersible water pump and 12V DC power adapter were shown in Figure 4.5. These components are connected and placed inside an electrical box.

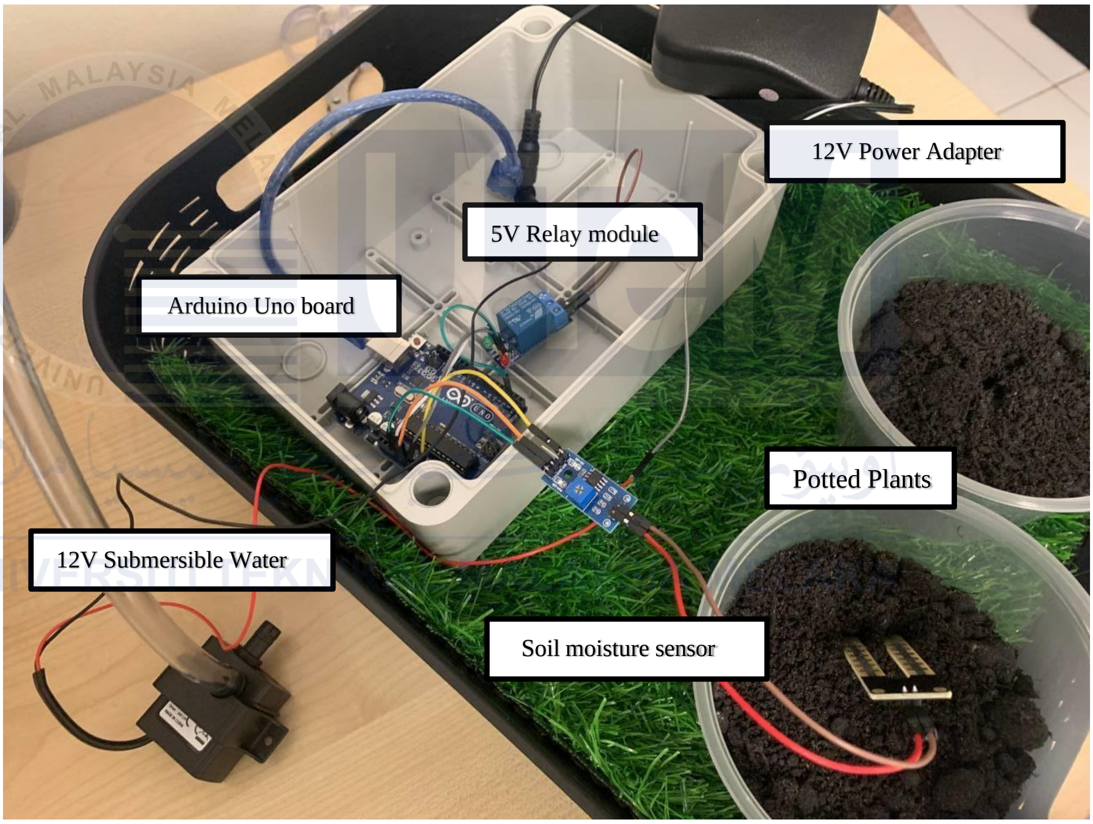


Figure 4.5 Full Connection of Smart Watet Irrigation System

4.2 Software Results

4.2.1 Arduino Serial Monitor

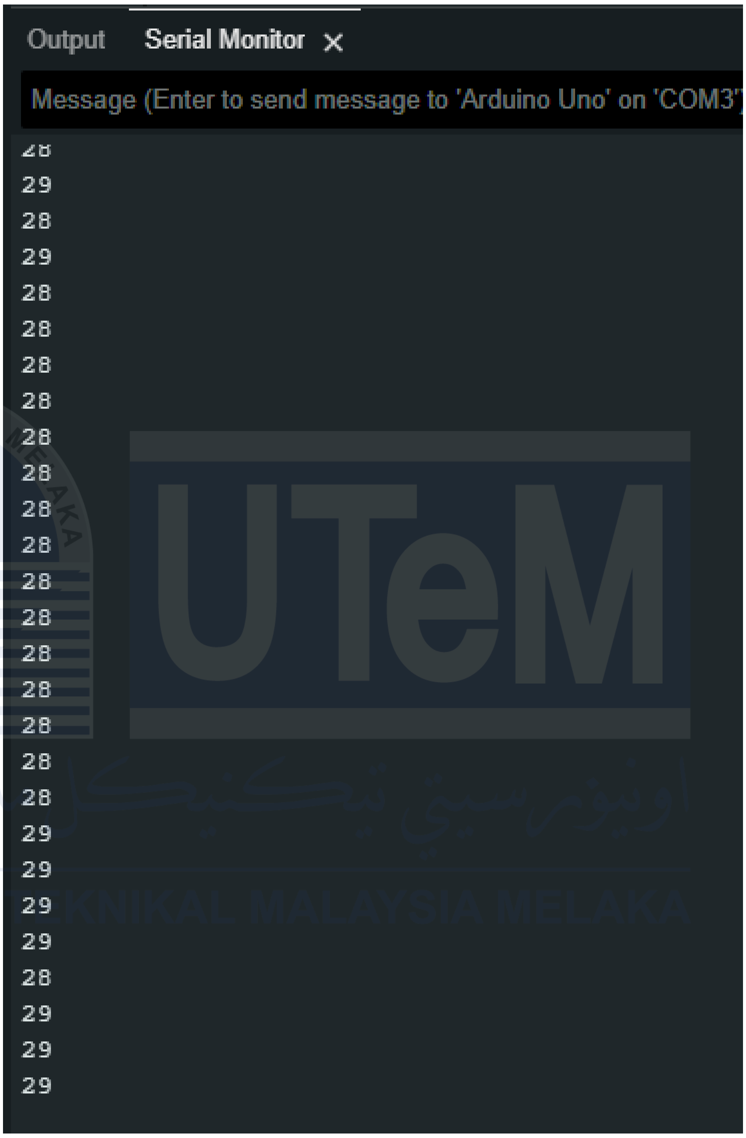


Figure 4.6 The soil moisture value after mapping into percentage when the soil moisture sensor is placed into dry Soil (0-31.6%)

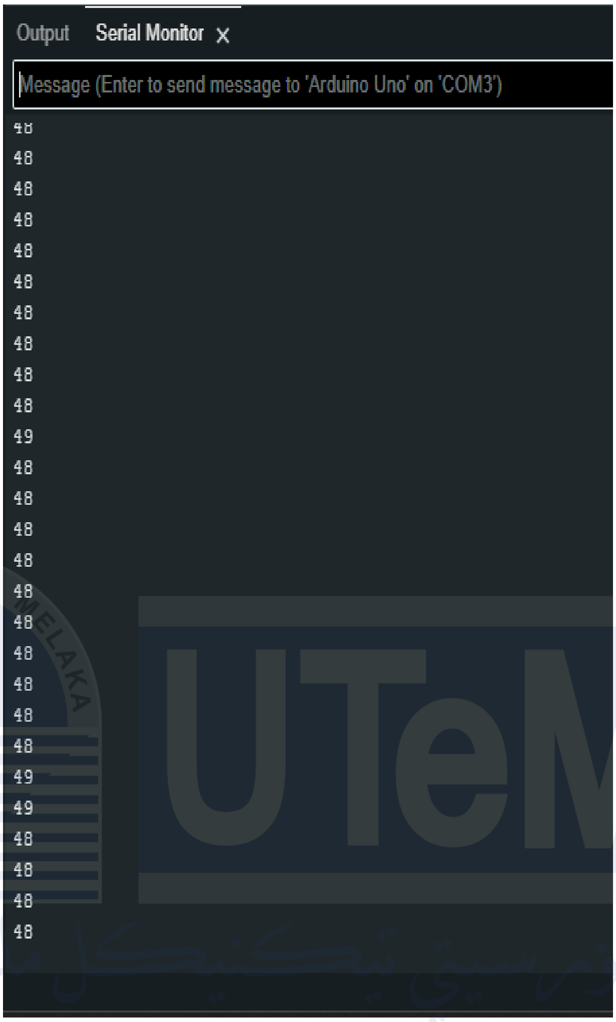


Figure 4.7 The soil moisture value after mapping into percentage when the soil moisture sensor is placed into Humid Soil (31.6%-73.7%)

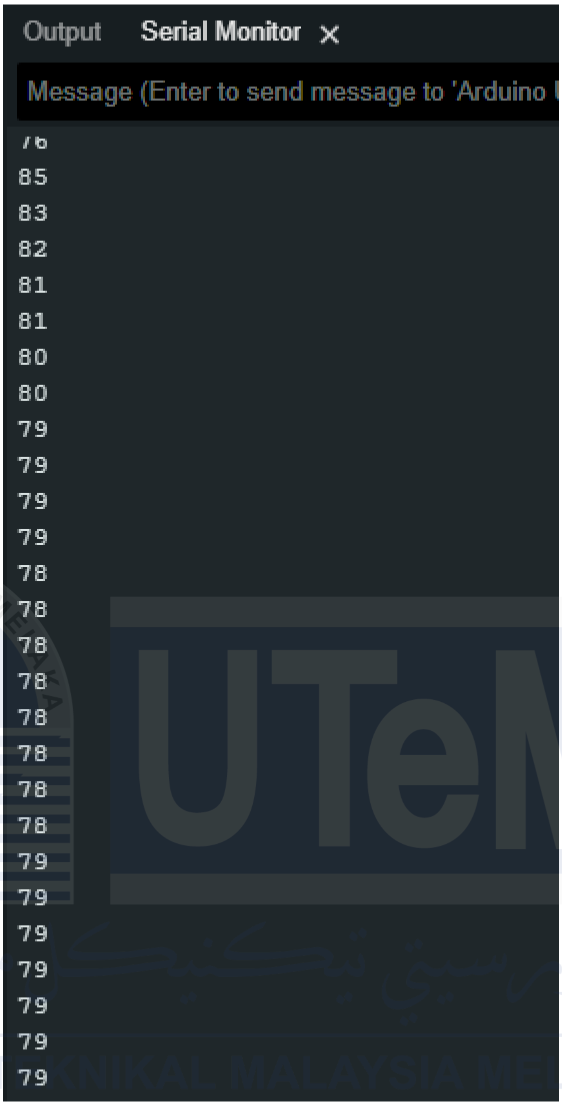
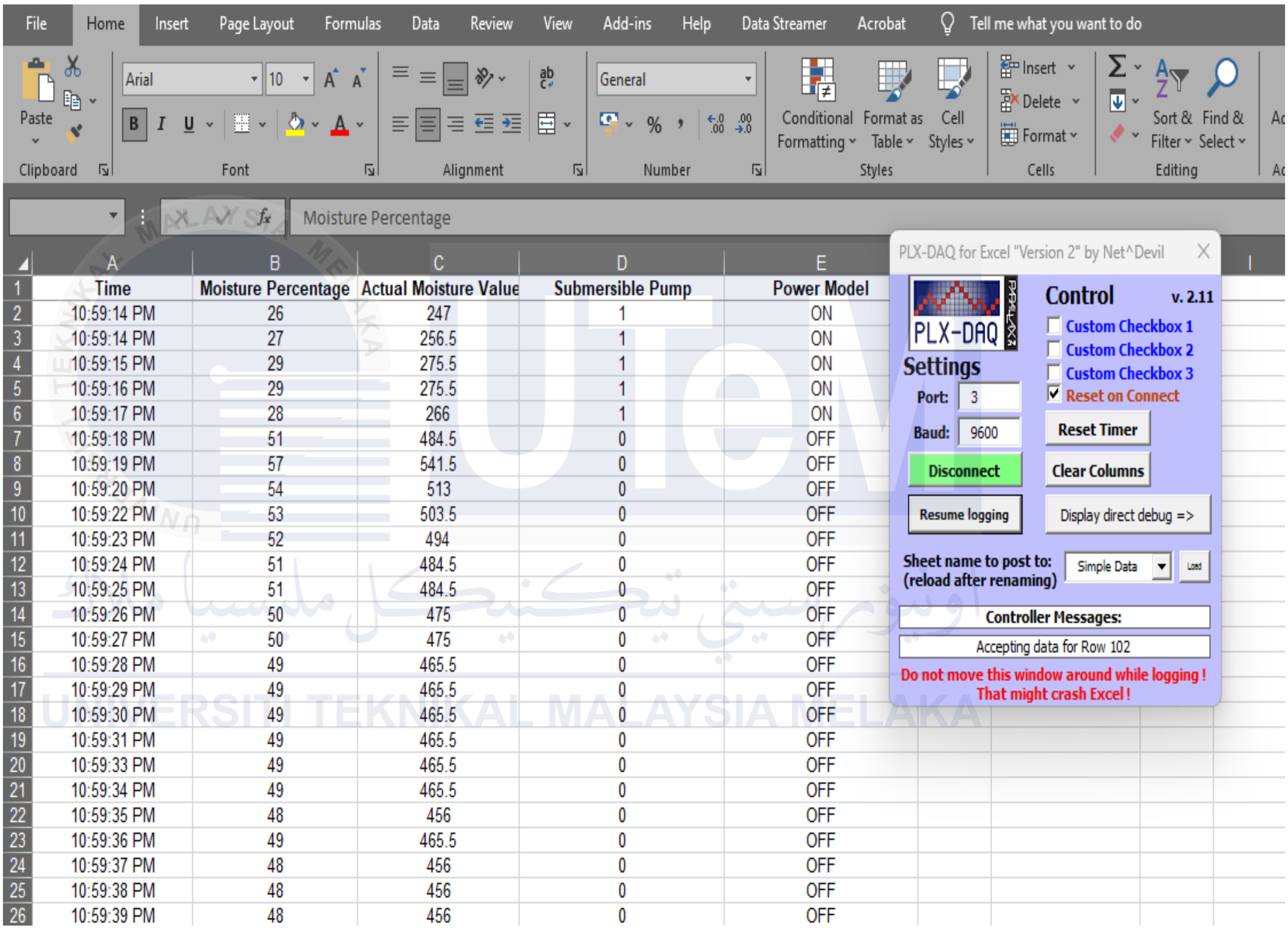


Figure 4.8 The soil moisture value after mapping into percentage when the soil moisture sensor is placed is soaked into water (73.7%-100%)

For figure 4.6, 4.7 and 4.8 are show the Arduino IDE serial monitor of the soil moisture value after mapping into percentage when the soil moisture sensor is placed into dry soil, humid soil and soaked into water. The software utilized is Arduino IDE software. The purpose of using this software is to program the smart water irrigation system in the microcontroller. The languages used to program this project are C and C++ language.

4.2.2 Result for Data logging of soil moisture data from Arduino IDE into Excel

PLX-DAQ provides simple spreadsheet Parallax microcontrollers. The data of soil moisture level obtained was logged from Arduino IDE into Excel to enable the data analysis, experimental analysis of the soil moisture sensor, real-time monitoring of irrigation system as well as the plotting of graph of soil moisture level in percentage against real time in seconds.



Time	Moisture Percentage	Actual Moisture Value	Submersible Pump	Power Model
10:59:14 PM	26	247	1	ON
10:59:14 PM	27	256.5	1	ON
10:59:15 PM	29	275.5	1	ON
10:59:16 PM	29	275.5	1	ON
10:59:17 PM	28	266	1	ON
10:59:18 PM	51	484.5	0	OFF
10:59:19 PM	57	541.5	0	OFF
10:59:20 PM	54	513	0	OFF
10:59:22 PM	53	503.5	0	OFF
10:59:23 PM	52	494	0	OFF
10:59:24 PM	51	484.5	0	OFF
10:59:25 PM	51	484.5	0	OFF
10:59:26 PM	50	475	0	OFF
10:59:27 PM	50	475	0	OFF
10:59:28 PM	49	465.5	0	OFF
10:59:29 PM	49	465.5	0	OFF
10:59:30 PM	49	465.5	0	OFF
10:59:31 PM	49	465.5	0	OFF
10:59:33 PM	49	465.5	0	OFF
10:59:34 PM	49	465.5	0	OFF
10:59:35 PM	48	456	0	OFF
10:59:36 PM	49	465.5	0	OFF
10:59:37 PM	48	456	0	OFF
10:59:38 PM	48	456	0	OFF
10:59:39 PM	48	456	0	OFF

27	10:59:40 PM	48	456	0	OFF
28	10:59:42 PM	48	456	0	OFF
29	10:59:43 PM	47	446.5	0	OFF
30	10:59:44 PM	47	446.5	0	OFF
31	10:59:45 PM	47	446.5	0	OFF
32	10:59:46 PM	47	446.5	0	OFF
33	10:59:47 PM	47	446.5	0	OFF
34	10:59:48 PM	47	446.5	0	OFF
35	10:59:49 PM	47	446.5	0	OFF
36	10:59:50 PM	47	446.5	0	OFF
37	10:59:51 PM	47	446.5	0	OFF
38	10:59:52 PM	47	446.5	0	OFF
39	10:59:54 PM	47	446.5	0	OFF
40	10:59:55 PM	47	446.5	0	OFF
41	10:59:56 PM	47	446.5	0	OFF
42	10:59:57 PM	47	446.5	0	OFF
43	10:59:58 PM	47	446.5	0	OFF
44	10:59:59 PM	47	446.5	0	OFF
45	11:00:00 PM	47	446.5	0	OFF
46	11:00:01 PM	68	646	0	OFF
47	11:00:02 PM	73	693.5	0	OFF
48	11:00:04 PM	68	646	0	OFF
49	11:00:05 PM	68	646	0	OFF
50	11:00:06 PM	67	636.5	0	OFF
51	11:00:07 PM	67	636.5	0	OFF
52	11:00:08 PM	66	627	0	OFF
53	11:00:09 PM	67	636.5	0	OFF
54	11:00:10 PM	70	665	0	OFF
55	11:00:11 PM	72	684	0	OFF
56	11:00:12 PM	68	646	0	OFF
57	11:00:13 PM	67	636.5	0	OFF
58	11:00:15 PM	67	636.5	0	OFF
59	11:00:16 PM	68	646	0	OFF
60	11:00:17 PM	67	636.5	0	OFF
61	11:00:18 PM	67	636.5	0	OFF
62	11:00:19 PM	68	646	0	OFF
63	11:00:20 PM	68	646	0	OFF
64	11:00:21 PM	68	646	0	OFF
65	11:00:22 PM	67	636.5	0	OFF
66	11:00:23 PM	68	646	0	OFF
67	11:00:24 PM	68	646	0	OFF
68	11:00:26 PM	68	646	0	OFF
69	11:00:27 PM	68	646	0	OFF
70	11:00:28 PM	68	646	0	OFF
71	11:00:29 PM	68	646	0	OFF
72	11:00:30 PM	68	646	0	OFF
73	11:00:31 PM	69	655.5	0	OFF
74	11:00:32 PM	70	665	0	OFF
75	11:00:33 PM	70	665	0	OFF
76	11:00:34 PM	70	665	0	OFF
77	11:00:36 PM	70	665	0	OFF
78	11:00:37 PM	70	665	0	OFF
79	11:00:38 PM	70	665	0	OFF
80	11:00:39 PM	70	665	0	OFF
81	11:00:40 PM	71	674.5	0	OFF
82	11:00:41 PM	75	712.5	0	OFF
83	11:00:42 PM	69	655.5	0	OFF
84	11:00:43 PM	64	608	0	OFF
85	11:00:44 PM	67	636.5	0	OFF
86	11:00:45 PM	65	617.5	0	OFF
87	11:00:47 PM	67	636.5	0	OFF
88	11:00:48 PM	73	693.5	0	OFF
89	11:00:49 PM	56	532	0	OFF
90	11:00:50 PM	53	503.5	0	OFF
91	11:00:51 PM	52	494	0	OFF
92	11:00:52 PM	70	665	0	OFF
93	11:00:53 PM	56	532	0	OFF
94	11:00:54 PM	62	589	0	OFF
95	11:00:55 PM	59	560.5	0	OFF
96	11:00:57 PM	52	494	0	OFF
97	11:00:58 PM	52	494	0	OFF
98	11:00:59 PM	52	494	0	OFF
99	11:01:00 PM	52	494	0	OFF
100	11:01:01 PM	52	494	0	OFF

Figure 4.9 Result from Data Logging of Soil Moisture Percentage as Real Time

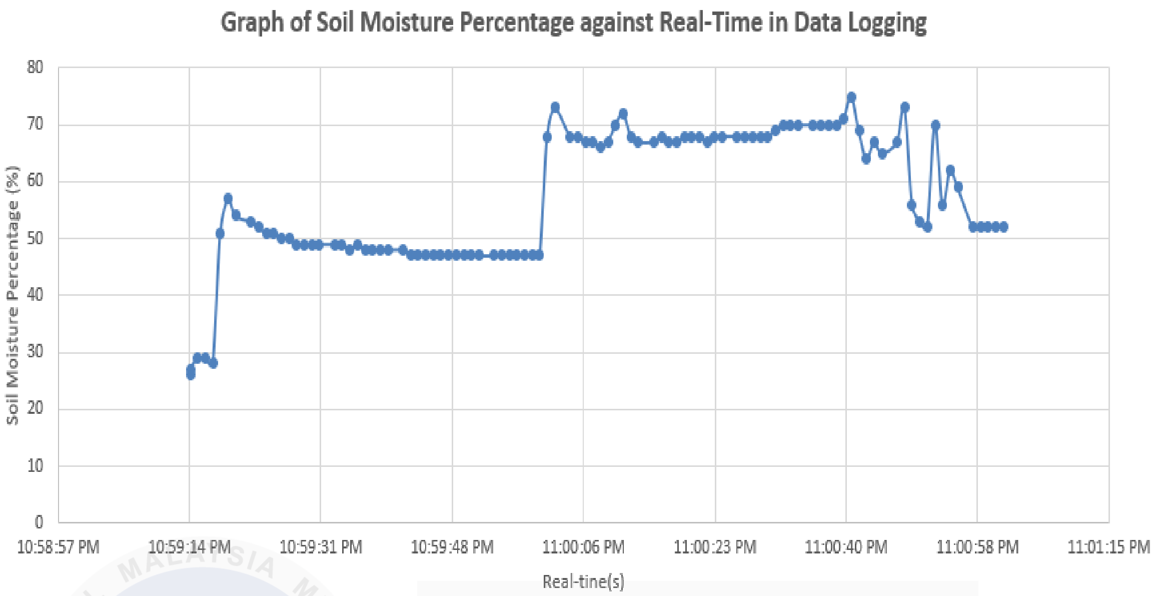


Figure 4.10 Graph of Soil Moisture Percentage against Real-Time in Data Logging

For figure 4.9 and figure 4.10 above show the result of the dry soil moisture percentage is at 26%, thus the submersible pump is turned on to enable water flow towards the potted plants until the soil moisture percentage reaches 51% that is more than 31.6% as set in programmed when the soil is humid. This result takes few seconds for soil to turn humid. After the potted plants are watered, the soil moisture will remain and this result will take time for the next water pumping.

4.3 Project Analysis

According to the theoretical result from datasheet, the soil moisture value when the soil moisture sensor is placed into dry soil, and humid soil then it is soaked into water should as shown in Table 4.

	Parameter	Soil Moisture Level in Value		Soil Moisture Level in Percentage (%)	
		Min	**Max**	**Min**	**Max**
Output Value	**Sensor in dry soil**	0	300	0	31.6
	Sensor in humid soil	300	700	31.6	73.7
	Sensor in soaked water	700	950	73.7	100

Table 4 The soil moisture level in value and in percentage when the soil moisture sensor is placed into dry soil, humid soil and soaked water.

From the table 4 above, we can see water that flowed to the potted plants will make the soil more prone to electric conductivity, resulting in less resistance in soil. This implies that dry soil has poor electrical conductivity, thus more resistance in soil and less soil moisture value and soil moisture percentage as compared to humid soil. The soil moisture percentage is obtained by manual calculation and this soil moisture percentage will be applied in Arduino IDE to map the soil moisture value into percentage.

$$\frac{\textbf{Soil moisture level } (\%) \textbf{ from serial monitor } \times \textbf{ Soil moisture level in value}}{\textbf{Soil moisture level in percentage}}$$

4.3.1 The Condition of Submersible Pump when the Detection of Moisture Level of Potted Plant by Remaining the Soil Moisture Sensor in the Soil from 1030am to 1030pm with 1 hour interval. (Day1 to Day2, within 1 hours)

Day 1:

Test Time in hours (h)	**Soil Moisture level in percentage (%) From serial monitor**	**Soil Moisture levels in value (Result by calculation)**	**Condition of soil Detected**	**Condition of Pump**	**Pumping of water towards potted plants**	**Condition of soil moisture**
1030	15	142.4	Dry Soil	ON	YES	OUTDOOR
1130	64	607.9	Humid soil	OFF	NO	OUTDOOR
1230	61	579.4	Humid soil	OFF	NO	OUTDOOR
1330	58	550.9	Humid soil	OFF	NO	OUTDOOR
1430	57	541.4	Humid Soil	OFF	NO	OUTDOOR
1530	49	465.4	Humid Soil	OFF	NO	OUTDOOR
1630	45	427.4	Humid Soil	OFF	NO	OUTDOOR
1730	28	265.8	Dry	ON	YES	OUTDOOR

			soil			
1830	68	645.9	Humid Soil	OFF	NO	INDOOR
1930	66	626.9	Humid soil	OFF	NO	INDOOR
2030	64	607.9	Humid soil	OFF	NO	INDOOR
2130	64	607.9	Humid soil	OFF	NO	INDOOR
2230	65	607.9	Humid soil	OFF	NO	INDOOR

Table 5: The condition of Submersible Pump when the Detection of Soil Moisture Level of Potted Plant from 1030am to 2230pm with 1 hour interval for Day 1

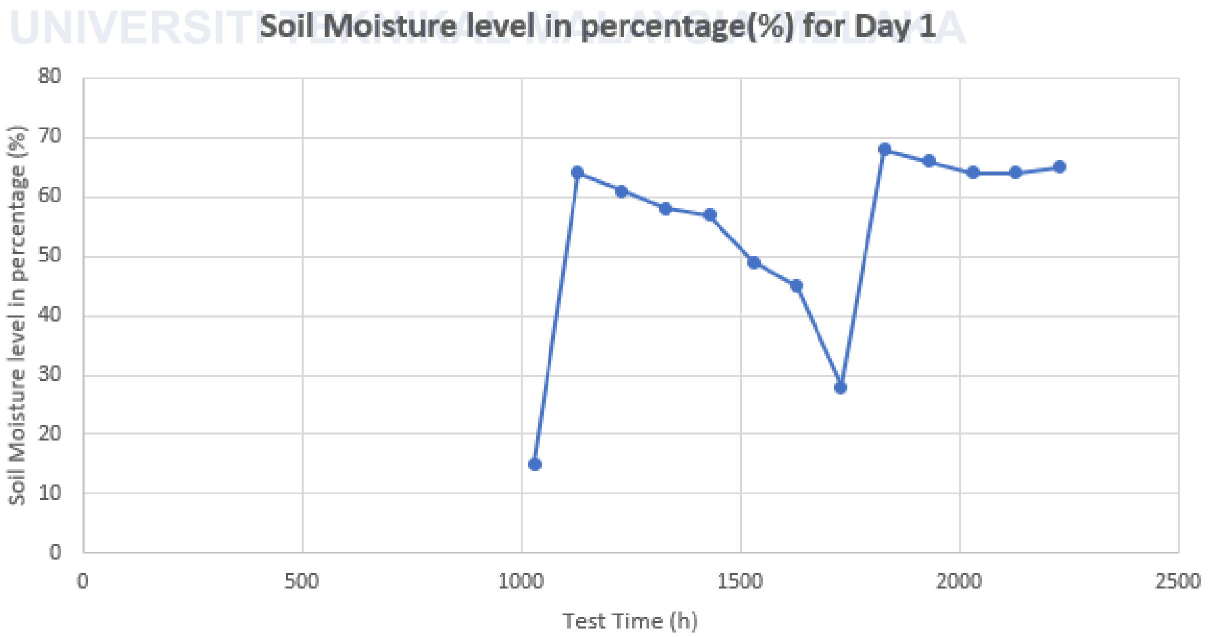


Figure 4.11 Graph of Soil moisture level in Percentage for Day 1

Table 5 shows the results of submersible pump condition when the detection of soil moisture percentage of potted plants for Day1. The data is taken every hour from 1030am to 2230pm. graph of soil moisture percentage against test time is plotted as displayed in Figure 4.11.

Day 2:

Test Time in hours (h)	**Soil Moisture level in percentage (%) From serial monitor**	**Soil Moisture levels in value (Result by calculation)**	**Condition of soil Detected**	**Condition of Pump**	**Pumping of water towards potted plants**	**Condition of soil moisture**
1030	54	512.9	Humid Soil	OFF	NO	OUTDOOR
1130	58	550.9	Humid soil	OFF	NO	OUTDOOR
1230	53	503.4	Humid soil	OFF	NO	OUTDOOR
1330	49	465.4	Humid soil	OFF	NO	OUTDOOR
1430	45	427.4	Humid Soil	OFF	NO	OUTDOOR
1530	44	417.9	Humid Soil	OFF	NO	OUTDOOR
1630	33	313.4	Humid Soil	OFF	NO	OUTDOOR

1730	26	246.8	Dry soil	ON	YES	OUTDOOR
1830	68	645.9	Humid Soil	OFF	NO	OUTDOOR
1930	71	674.4	Humid soil	OFF	NO	INDOOR
2030	71	674.4	Humid soil	OFF	NO	INDOOR
2130	70	664.9	Humid soil	OFF	NO	INDOOR
2230	68	645.9	Humid soil	OFF	NO	INDOOR

Table 6 The condition of Submersible Pump when the Detection of Soil Moisture Level of Potted Plant from 1030am to 2230pm with 1 hour interval for Day 2.

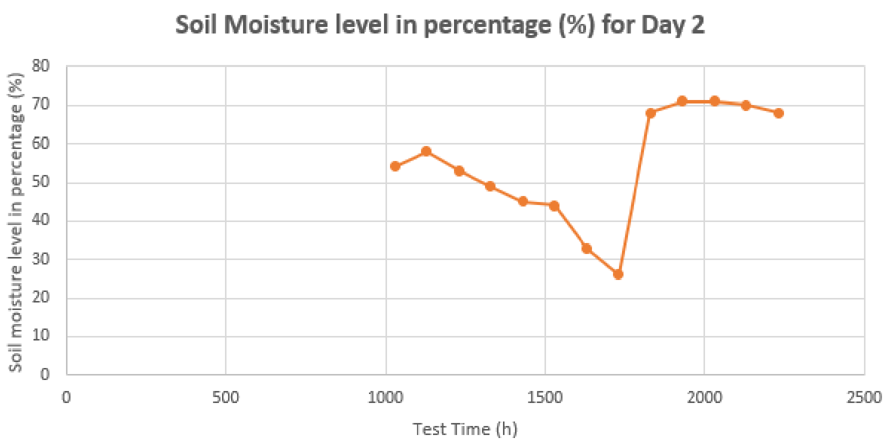


Figure 4.12 Graph of Soil moisture level in Percentage for Day 2

Table 6 shows the results of submersible pump condition when the detection of soil moisture percentage of potted plants for Day 2. The data is taken every hour from 1030am to 2230pm. A graph of soil moisture percentage against test time is plotted as displayed in Figure 4.12.

4.3.2 The Soil Moisture Level in Percentage for Two Consecutive Days

Test Time (h)	Soil Moisture Level in Percentage (%)	
	Day 1	Day 2
1030	15	54
1130	64	58
1230	61	53
1330	58	49
1430	57	45
1530	49	44
1630	45	33
1730	28	26
1830	68	68
1930	66	71
2030	64	71
2130	64	70
2230	65	68

Table 7 The Soil Moisture Level in Percentage (%) against Test Time (h) for Two

Consecutive Days

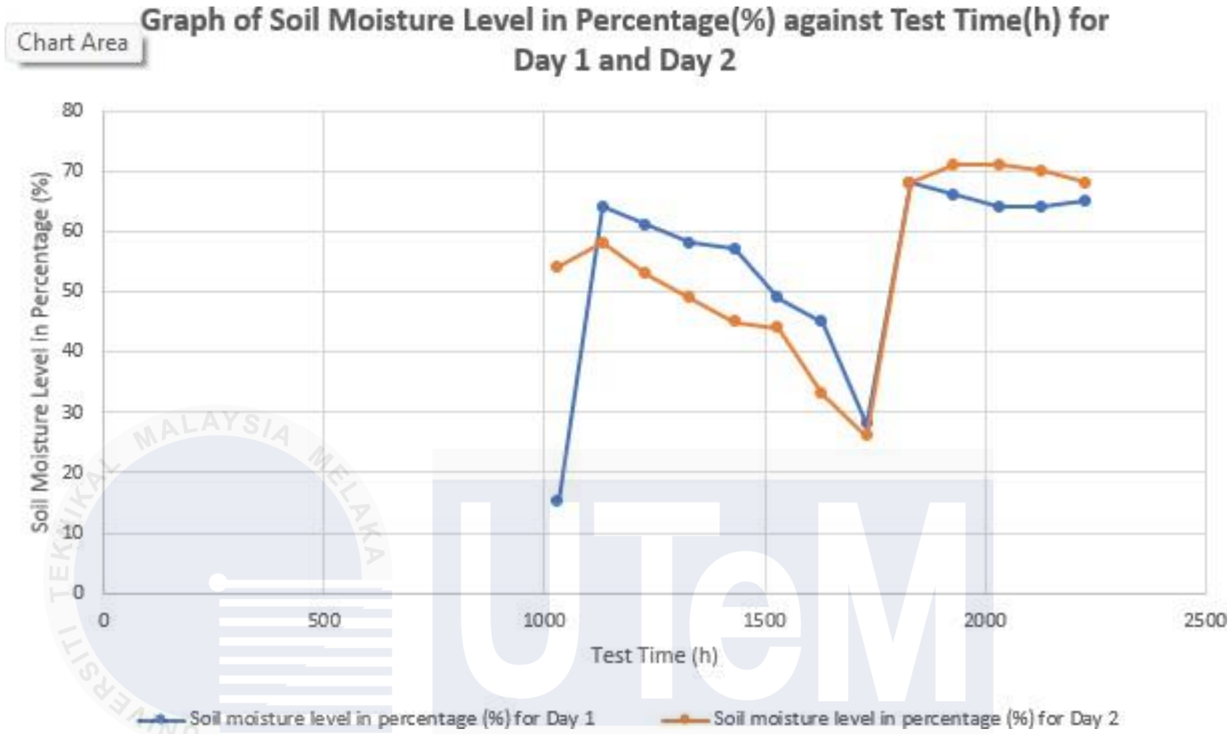


Figure 4.13 Graph of Soil Moisture Level in Percentage against Test Time for Two Consecutive Days

Table 7 shows the results of submersible pump condition when the detection of soil moisture percentage of potted plants for Day1 and Day2. The data is taken every hour from 1030am to 2230pm. A graph of soil moisture percentage against test time is plotted as displayed in Figure 4.13.

4.3.3 The Conditions of Submersible Pump upon Detection of Moisture Level when the Soil Moisture Sensor is pulled out from Soil and Placed in Two Potted Plants.

Since that two potted plants are used to take the results of soil moisture percentage, hence an investigation is taken to check the soil moisture percentage of both plants in a day. These results obtained are recorded and tabulated in Table 8. Then, for the graph of soil moisture percentage for two potted plants against test time is plotted as shown as Figure 4.14. The results of soil moisture's graph for two potted plants are consistency.

Test Time in hours (h)	**Soil Moisture level in percentage (%) From serial monitor**		**Soil Moisture levels in value (Result by calculation)**		**Condition of Submersible Pump**		**Pumping of water towards potted plants**
	Plotted Plant 1	**Plotted Plant 2**	**Plotted Plant 1**	**Plotted Plant 2**	**Plotted Plant 1**	**Plotted Plant 2**	
1030	5	4	47.5	38	ON	ON	YES
1130	44	43	417.9	408.4	OFF	OFF	NO
1230	35	32	332.4	303.9	OFF	OFF	NO
1330	29	30	275.3	284.8	ON	ON	YES
1430	28	30	265.8	284.8	ON	ON	YES
1530	33	36	313.4	341.9	OFF	OFF	NO
1630	28	30	265.8	284.8	ON	ON	YES
1730	50	53	474.89	503.4	OFF	OFF	NO
1830	39	41	370.4	389.4	OFF	OFF	NO
1930	33	36	313.4	341.9	OFF	OFF	NO

2030	29	30	275.3	284.8	ON	ON	YES
2130	28	30	265.8	284.8	ON	ON	YES
2230	28	30	265.8	284.8	ON	ON	YES

Table 8 The Condition of Submersible Pump when the Soil Moisture Sensor is used to Detect Moisture Percentage of Two Potted Plants.

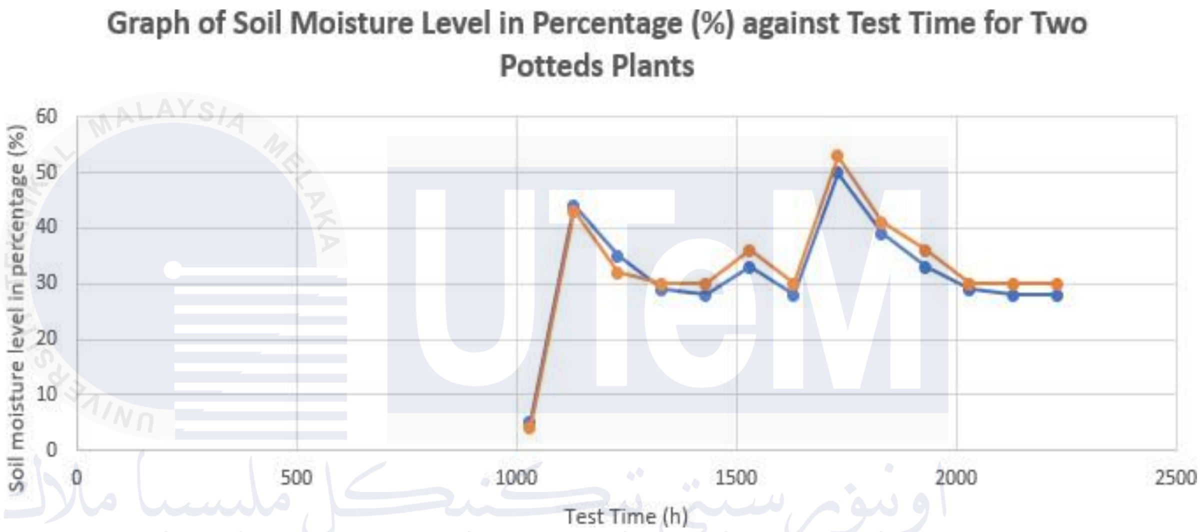


Figure 4.14 Graph of Soil Moisture Level in Percentage for Two potted Plants

4.3

Discussion

In this project, an Smart Water Irrigation System is designed and created according to the desired soil moisture percentage set in relevant to the theoretical soil moisture level. First of all, the circuit for this project designed using Fritzing Software is constructed as hardware. The connection between Arduino Uno, soil moisture sensor, 12V Power Adapter, 5V relay module and 12V DC submersible water pump is established as displayed in Figure 4.4. These components are connected and placed inside an electrical box. A smart water irrigation system prototype is then created.

Next, the result of soil moisture percentage is taken and recorded. Based on the theoretical result from Table 4, the soil moisture values when the soil moisture sensor is placed in dry soil, humid soil, and soaked into water are 0~300, 300~700, and 700~950 respectively. After mapping into percentage, the soil moisture level should be 0~31.6%, 31.6%~73.7% and 73.7%~100% respectively when the soil moisture sensor is placed in dry soil, humid soil, and soaked into water. This theoretical result is verified by using soil moisture sensor with the experimental results read from serial monitor.

For Table 5 to Table 6 show the result obtained for soil moisture level in percentage when test time varied from 1030am to 2230pm for Day 1 and Day 2 respectively. From Table 5, it can be observed that the submersible water pump turn ON twice is during 1030am to 1730pm at the soil moisture level of 5% and 28% sequentially on Day 1. Next, for the Table 6 displays the soil moisture level in percentage when test time varied from 1030am to 2230pm for Day 2. The submersible water pump only turned ON once at 1730pm when the soil moisture percentage was detected at 26% by the soil moisture sensor. Each graph of soil moisture percentage (%) against real time (h) was plotted as shown In Figure 4.12 to Figure 4.14. Precaution such that the 12V DC power adapter must be switched on to turn on the pump when the soil moisture percentage is low.

Meanwhile, the summarization of the soil moisture percentage for the two consecutive days is presented in Table 7. This is done to ease the analysis and the comparison of the soil moisture percentage for the two days taken for this experiment. The Submersible water pump will be programmed using Arduino IDE software to enable water flow towards the plants when the soil moisture percentage is more than 31.6%. Then, the graph of soil moisture percentage (%) against real time (h) was then plotted as shown in Figure 4.15.

After that, the condition of submersible water pump upon detection of moisture level when the soil moisture sensor is placed in two plotted plants respectively for every measurement are recorded as shown in Table 8. Based on Table 8, it is discovered that the soil moisture percentage is relatively similar for two potted plants. This is because both potted plants share the same piping system for watering purpose under the same condition. This project system used is dripping irrigation that is more suitable for potted plants. Hence, the equally amount of water is flowed towards the potted plants to keep the soil humid.

Lastly, the data logging is done to send the data of soil moisture percentage directly from the Arduino Uno into the columns of Excel. This data logging enables the data analysis, experimental analysis of soil moisture sensor and real-time monitoring of irrigation system. In these circumstances, the graph data of soil moisture level can be plotted as it arrives in real-time. After the potted plants are watered, the soil moisture will remain and this will take time for the next water pumping. Whereas the graph of soil moisture percentage against time is show as in Figure 4.11 in data logging.

4.4 The Summarization of the System Work [21]

Soil Moisture Level (in value)	**Soil Moisture Level in percentage (%)**	**Condition of Soil Moisture Sensor**	**Condition of 12V Power Adapter**	**Condition of submersible pump**	**Pumping of water towards potted plants**
0-300	**0-31.6**	**Placed in Dry Soil**	ON	ON	YES
			OFF	OFF	NO
300-700	**31.6-73.7**	**Placed in Humid Soil**	ON	OFF	NO
			OFF	OFF	NO
700-950	**73.7-100**	**Soaked into water**	ON	OFF	NO
			OFF	OFF	NO

Table 9 Summarization of the System Work

Overall, the Smart Water Irrigation System should function according to the Table 9 above whereby the 12V DC submersible water pump is turned ON to allow the pumping of water only when the soil is sensed dry by the soil moisture sensor when it is in the range within 0 to 300, or 0% to 31.6% after mapping into percentage when the 12V DC submersible water pump should be turned OFF to stop the pumping of water when the soil is detected in humid state using soil moisture sensor, that is withing 300 to 700, or 31.6% to 73.7% after mapping into percentage regardless the 12V DC power adapter is turned ON or OFF.

CHAPTER 5

CONCLUSION & FUTURE WORK

This chapter covers the conclusion of the overall project. Apart from that, future work that can be utilized to improve the project will be discussed in this chapter.

5.1 Conclusion

At the end of this project, all the objectives were achieved successfully. The design of Smart Water Irrigation System is studied and is created using Arduino Uno. A smart water irrigation system is developed successfully. Its functionality has been tested together with the soil moisture sensor. This smart water irrigation system will pump the water towards potted plants automatically when the soil moisture level is low. The soil moisture values when the soil moisture sensor is placed in dry soil, is placed in humid soil and is soaked into water are 0-300, 300-700 and 700-950 respectively. After mapping into percentage, the soil moisture level will be at 0-31.6%, 31.6-73.7% and 73.7-100% respectively when the soil moisture sensor is placed in dry soil, is placed in humid soil and is soaked into water.

The prototype has been successfully developed with the application of dripping irrigation. The system will pump the water towards the potted plants via the transparent hose with dripping irrigation and the pumping of water towards the plotted plants will be stopped upon the detection of humid soil moisture level. Since the both plotted plants share the same piping system with dripping irrigation, the soil moisture percentage is relatively similar for the two plotted plants. Hence, both plants will receive an almost equal amount of the water to keep the soil humid. Along with the same lines, this dripping irrigation also supports fertigation to provide nutrition to the plants.

Other than that, the data obtained from soil moisture level will be auto-logged and displayed in Microsoft Excel using PLX-DAQ Spreadsheet. This data logging enables the data analysis, experimental analysis of soil moisture sensor and real-time monitoring of watering system. Then, a graph of soil moisture level against real time is plotted in the Microsoft Excel. The performance and functionality smart water irrigation system are analyzed as shown in discussion part.

Overall, the system is typically designed and created for house owner who far away from home or for those plant lovers who are having an hectic lifestyle and has no time to take care of their plants. To add on, it is designed to deal with people laziness in watering system, particularly during summer or during hot weather days. Therefore, the contribution of people in planting is expected to aid in tackling greenhouse effects as well as to help in lowering surrounding temperature.

5.2 Future Work

The smart water irrigation system that has been created can be further enhanced for future work. In this case, the enhancements that can be made are the sensor and technology used for this project created. Several ideas and recommendations are suggested for future research and development in order to improve the present smart water system.

First, one of the improvements that can be made is replacing the current soil moisture sensor to DHT11 humidity and temperature sensor. Generally, this DHT11 humidity and temperature sensor is a composite sensor that contains a calibrated digital signal output of the temperature and humidity Besides that, this humidity and temperature sensor has the advantages of fast response, strong anti-interference ability, long distance signal transmission and excellent long-term stability compared to the current soil moisture sensor.

Other than that, this smart water irrigation system can be applied to greater usage in farming. Technology such as GSM can be applied to the present smart irrigation system. The function for this technology is to notify the owner when there is a owner through GSM technology and the owner can switch off the main switch off the main switch by replying the warning message. By applying this technology, wasting of water can be prevented and hence, a more effective smart water irrigation system will be produced.

Along with the same line, an android application can be developed in order to enhance the present smart water irrigation system. Through this app, owner can receive message when the plants are watered. Also, the android application can be created to control the smart water irrigation system such as control the flow of water and the volume of water flows.

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APPENDICES

APPENDIX A- Coding of Data Logging when Moisture Level Detection using Arduino IDE software

APPENDIX B - Coding of Smart Water Irrigation System using Arduino IDE software

APPENDIX C - Datasheet Arduino Uno

APPENDIX A

Coding of Data Logging when Moisture level defection using Arduino IDE software

```
/* soil moisture value description
# 0~300 when soil moisture sensor detected dry soil
# 300~700 when soil moisture sensor detected humid soil
# 700~950 when soil moisture sensor soaked in water */

/* soil moisture percentage description
# 0~31.6%  when soil moisture detected dry soil
# 31.6%~73.7%  when soil moisture sensor detected humid soil
#73.7%~100%  when soil moisture sensor soaked in water
*/

int submersiblePump=2;

int row =0;
String a = "";
String b = "";

void setup() {

  Serial.begin(9600);
  pinMode(submersiblePump,OUTPUT);

  Serial.println("CLEARDATA");
  Serial.println("LABEL,Time,Moisture Percentage, Actual Moisture Value,Submersible
Pump,Power Model");
}

void loop()
{
```

```
int soil_moisture_value = analogRead(A0);

double soil_moisture_percentage = map(soil_moisture_value,950,0,0,100);
Serial.println(soil_moisture_percentage);
delay(100);

double c = ((soil_moisture_percentage/100)*950);
Serial.println(c);

if(soil_moisture_percentage<31.6)
{
  digitalWrite(submersiblePump,HIGH);
  a = digitalRead(submersiblePump);
  Serial.println(a);

  b = "ON";
  Serial.println(b);

}
else{

  digitalWrite(submersiblePump,LOW);
  a = digitalRead(submersiblePump);
  Serial.println(a);

  b = "OFF";
  Serial.println(b);
}

{
```

```
    Serial.print("DATA,TIME,");
    Serial.print(soil_moisture_percentage);
    Serial.print(",");
    Serial.print(c);
    Serial.print(",");
    Serial.print(a);
    Serial.print(",");
    Serial.println(b);
    row++;

    if (row > 1000)
    {
      row=0;
      Serial.println("ROW,SET,2");
    }
  }

    delay(1000);
}
```

APPENDIX B

Coding of Smart Water Irrigation System using Arduino IDE software

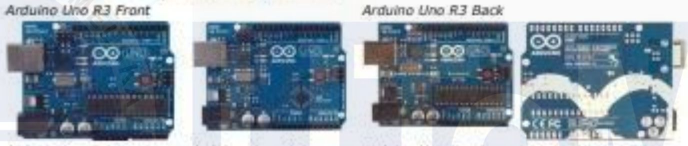
```
/*soil moisture value description
# 0~300 when moisture sensor detected dry soil
# 300~700 when moisture sensor detected humid soil
# 700~950 when moisture sensor soaked in water*/

int submersiblePump=2;

void setup () {

  Serial.begin(9600);
  pinMode(submersiblePump,OUTPUT);
}

void loop () {

  int soil_moisture_value=analogRead(A0);
  int soil_moisture_percentage=map(soil_moisture_value,950,0,0,100);//950 to 0, 0 to 100%
  Serial.println(soil_moisture_percentage);
  delay(100);
  if(soil_moisture_percentage);
  delay (100);
  if(soil_moisture_percentage<31.6)
  {digitalWrite(submersiblePump,HIGH);
  }
  else
  {digitalWrite(submersiblePump,LOW);
  }
}
```

APPENDIX C

DATASHEET OF ARDUINO UNO R3

Arduino Uno

Arduino Uno R3 Front *Arduino Uno R3 Back*



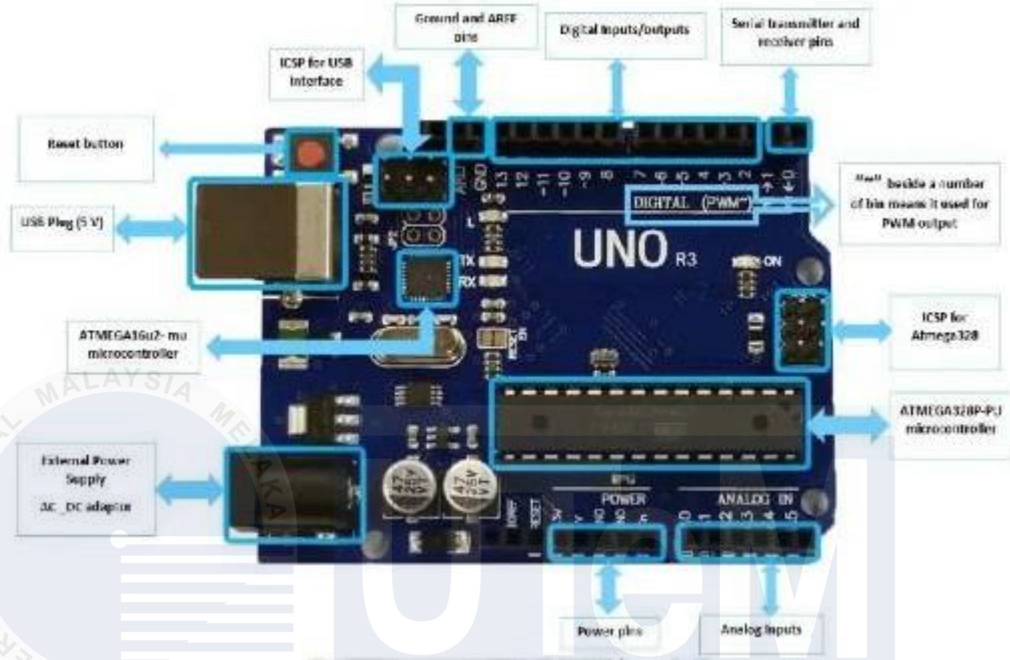
Arduino Uno R2 Front *Arduino Uno SMD* *Arduino Uno Front* *Arduino Uno Back*

Overview

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.
The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.
Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.
Revision 3 of the board has the following new features:

- 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.


Ground and AREF pins
Digital inputs/outputs
Serial transmitter and receiver pins
ICSP for USB interface
Reset button
USB Plug (5 V)
"~" beside a number of bin means it used for PWM output
UNO R3
ICSP for Atmega328
ATMEGA16u2- mu microcontroller
ATMEGA328P-PU microcontroller
External Power Supply
AC_DC adaptor
Power pins
Analog inputs