Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF SMART GARDEN BY USING ARDUINO

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Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

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A project report submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

Faculty of Electrical and Electronic Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this project report entitled "Development of Smart Garden by using Arduino" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ____________________

Student Name : MUHAMMAD SYAFIQ BIN SUHAIMI

Date : 10/1/2022

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 (Industrial Electronics) with Honours.

Signature : ....

Supervisor Name : TS. MOHD ERDI BIN AYOB

Date : 10/1/2022

Signature : ....

Co-Supervisor Name (if any) : ....

Date : ....

DEDICATION

I dedicate this project to my beloved parents for providing all the support and assistance that have made possible the fruition of our efforts. They have never given up and will always be remembered in this heart.

Next, I dedicate this project to my supervisor lecturer for all support and give full cooperation during Final Year Project. Your patience, knowledge, and words of encouragement gave me immense strength throughout the project.

Then, to all my friend's thanks for their cooperation, advice, motivation, and support while conducting the Final Year Project

To all lecturer, thank you for all their moral guidance and support during all this semester in Universiti Teknikal Malaysia Melaka

ABSTRACT

In today's technologically advanced era, several industries, particularly agriculture and horticulture, have risen in size over time. We can see clearly that entrepreneurs seeking to start a firm will undoubtedly focus on the tree planting sector, since it is capable of producing raw materials such as fruits, herbs, and medicines, as well as timber. As a result, everyone working in agriculture almost certainly has a crop irrigation system. This method is critical for maintaining the freshness and safety of the crops. This is because plants, like living organisms, require water to exist. Plants will grow if we water them on a regular basis, in the proper manner, and at the appropriate time. Additionally, by referencing unpredictable meteorological elements such as high heat, the concept of switching light sources for crops becomes more plausible. With that, the project addresses how to advance the newest smart garden technology in terms of automatically constructing water systems based on soil moisture and switching the light source for trees from sunshine to LED lighting. The system will thereafter be totally powered by solar energy, maximising electricity savings. The project will incorporate both software and hardware components. The programme will use Arduino to communicate with the hardware that will be tested on the crop.

ABSTRAK

Pada era teknologi yang maju sekarang ini, beberapa industri, khususnya pertanian dan hortikultur, telah meningkat dari masa ke masa. Kita dapat melihat dengan jelas bahawa pengusaha yang ingin memulakan sebuah syarikat pasti akan fokus pada sektor penanaman pokok, kerana ia mampu menghasilkan bahan mentah seperti buah, herba, dan ubat-ubatan, serta kayu. Hasilnya, setiap orang yang bekerja di pertanian hampir pasti mempunyai sistem pengairan tanaman. Kaedah ini sangat penting untuk menjaga kesegaran dan keselamatan tanaman. Ini kerana tumbuhan, seperti organisma hidup, memerlukan air untuk wujud. Tumbuhan akan tumbuh jika kita menyiramnya secara berkala, dengan cara yang betul, dan pada waktu yang sesuai. Selain itu, dengan merujuk unsur meteorologi yang tidak dapat diramalkan seperti panas tinggi, konsep menukar sumber cahaya untuk tanaman menjadi lebih masuk akal. Dengan itu, projek ini membahas bagaimana untuk memajukan teknologi taman pintar terbaru dari segi membina sistem air secara automatik berdasarkan kelembapan tanah dan menukar sumber cahaya untuk pokok dari cahaya matahari ke pencahayaan LED. Sistem ini akan dikuasakan sepenuhnya oleh tenaga suria, memaksimumkan penjimatan elektrik. Projek ini akan merangkumi kedua-dua komponen perisian dan perkakasan. Program ini akan menggunakan Arduino untuk berkomunikasi dengan perkakasan yang akan diuji pada tanaman.

ACKNOWLEDGEMENTS

First and foremost, Thanks to Allah Almighty Who enabled me to research on this project and for all the countless gifts You have offered me.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

In this chapter, we will describe information regarding the use of tree plant technology, the basics of Arduino, project background, project problem statement, objectives to be found in this project, project scope, and thesis organization.

1.1 Background of Project

It is not as simple as one might imagine to create a plant. Heat, soil moisture, the demand for irradiation or the intensity of light employed, and other elements all have an effect on the growth of the plant. Numerous scientists are now working on more advanced agricultural technology systems as a result of this. One of the devices in use is electronic technology. A Smart Garden system, which is an automatic watering device that is controlled by soil moisture, is one of the most recent advancements in agricultural technology to emerge from the field of electronics. This technology is based on the soil moisture level, which means that if the soil is dry, this tool will automatically water the plants, and if the humidity is sufficient, this tool will automatically close. The development of instruments to aid and promote human work, such as guessing or measuring soil quality or plant water requirements, is one strategy to resolve this issue. Soil moisture values may be determined more accurately and efficiently with the help of this smart garden system.

The next step is to replace natural sunshine with LED lighting for plant growth. Plant light or growth light is an artificial light source. The purpose of employing electric light bulbs is to encourage the growth of plant life. With this technology, scientists want to create an electromagnetic spectrum that is favourable to photosynthesis. Growth light is utilised when natural light (sunlight) is insufficient or when more light is required. As an example, in a place that experiences winter and receives less sunshine, which is less desirable for plant growth, growth lights can be utilised to offer additional light to a plant. Research and analysis conducted by scientists and arborists has revealed that the light used on plants has specific features.

1.2 Objectives

The objective of the study in this project is to test the level of effectiveness of the way of growing and caring for crops using current technology compared to traditional crops. Therefore, the main objectives of this project are:

I. To study and verify the effectiveness of four type LED color which is red, blue, ultraviolet and white that will be used as a source in the process of tree photosynthesis.

II. To create automatic control system that can measure the parameter related to agriculture without implementation internet of things due to lack of internet affordability.

III. To verify the use of electronic technology on crops can help in terms of tree growth, efficiency in time and manpower, and affordability of the equipment or components used.

1.3 Problem Statement

Tree planting technology can improve the quality of crops which can contribute to the greenery of the environment and can also prevent plant extinction. But as we have seen, at the moment the weather is extremely erratic. Therefore, the processing of light from solar sources in the process of photosynthesis must be transformed into a more systemic and harmless mechanism for plants. Therefore, this solution can be implemented with the current lighting technology that is Light Emitted Diode (LED). The use of LED systems for lighting has actually been implemented by some gardeners or scientists but the selection of the light spectrum and inaccurate brightness makes the plants not grow or stunted. So, for solution and enlightenment, this project will study and analyze crop data using proper spectral light by creating light systems as well as related crop control systems.

1.4 Scope of Project

As various weather elements have also allowed for major changes in crops, the project will develop a control system and data collection to streamline the cropping process. First, the Arduino Nano will be chosen as the main configuration because it is capable of integrating drive components as well as controllers with easy -to -understand language chess. Therefore, there are several systems that will be controlled by this Arduino that can help the crop process, including soil moisture control system, temperature and humidity control system, plant data storage system and solar energy system. Therefore, all these systems will be set up without the use of internet technology now as smart systems crop using the internet of things. This is because to solve the lack of internet resources. Going back to all the systems in this project, in a nutshell, Arduino will programme sensors such as soil moisture sensors to detect soil moisture that will control water pump motors, temperature and humidity sensors for the purpose of controlling ventilation around crop areas, and finally as a platform for transmitter and receiver the data plant. Furthermore, a lighting system using high power LEDs without Arduino will be built as well. This project has also shifted the focus from outdoor cultivation towards indoor cultivation, where one can cultivate regardless of the space available.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter describes in more detail the previous topics and literature review related to the main system that will be used in this project, which is an irrigation system. In addition, it covers the development of smart gardens over time, the use of light types in agriculture as well as solar functions for storing energy.

2.1 Information to Smart Garden

Smart gardens may be grouped into two sections: indoor and outdoor. Plant development is impacted by a range of elements that aren't usually connected to whether the plant is inside or outside. Plants require a few essential conditions to grow. Water, nutrients, light, and carbon dioxide are all required. A human can supply water to a plant whether it is maintained inside or outside, although being outside is preferred because water is not a precious resource. The same is true of nutrition. Plants obtain their nutrients from the soil they are planted in. Thus, if a farmer prepares by planting with appropriate fertilizer, the plant should be healthy whether it is inside or outdoors. When you contemplate how big the plant will grow, you're bound to run into difficulty. Because plants require sunshine to thrive, it looks like they should be maintained outside, but if you are prepared to acquire specialized light bulbs that resemble the sun, you may keep the plant indoors. Plants can also be stored near a window, but keep in mind that the sun may not shine through the glass all day. Finally, plants require carbon dioxide, a gas found in the environment, to grow. While carbon dioxide may be found everywhere, it is more concentrated inside dwellings than outside. This is because humans create carbon dioxide by breathing, and much of it is confined indoors.

2.1.1 Type of Smart Garden

The most prevalent smart garden-related primary system presently is irrigation. There are several variations or ways to regulate the water via mechanical or electrical systems to feed the plant. The reason why the irrigation system has to be monitored is because it avoids water waste and wants to maintain the soil's sustained wetness, so that the plants may develop extremely healthily. According to (Al-Omary, AlSabbagh and Al-Rizzo, 2018), garden irrigation may be converted from manual and static to smart and dynamic by automating the monitoring process. This results in better comfort, more efficient water consumption, and less human oversight. Soil moisture can modify the watering requirements of a plant. Measuring plant soil moisture tells you if the plant is appropriately watered, overwatered, or underwatered.

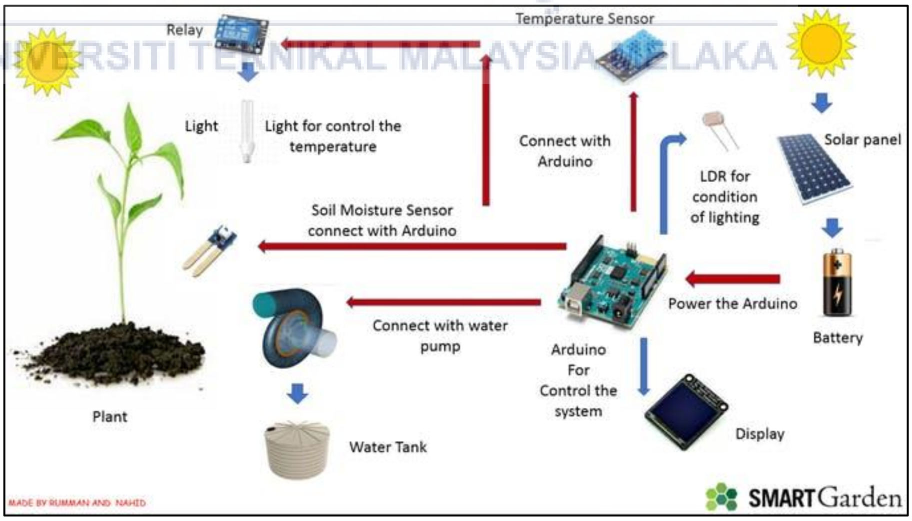


Figure 2.1: Conventional System of Smart Garden

2.2 Light of LED Imitate from Sunlight in Agriculture

Light supplementation can enhance agricultural productivity by increasing photosynthesis and plant development. On the other hand, high energy costs associated with light supplementation are a key barrier restricting the growth and advancement of controlled-environment farming. LEDs are a promising technology with huge promise for improving irradiance efficiency and replacing traditional horticulture lighting. LEDs provide notable benefits over traditional crop light sources (e.g. high-pressure sodium lamps and metal halide lamps), such as compact size, extended life and high photoelectric conversion efficiency,(Bian *et al.*, 2018).

2.2.1 Introduction to Light Emitting Diode (LED)

In 1962, Nick Holonyak Jr. ("the father of a diode of light-emitting") designed the first LED which, while at General Electric, created visible red light. The term "LED" refers to a light source that generates light when current flows through a semiconductor. Electrons recombine with electron holes in the semiconductor to emit energy in the form of photons. The energy required for electrons to pass the semiconductor band gap determines the hue of light (equivalent to photon energy). White light is produced by combining numerous semiconductors or by coating the semiconductor with a phosphorous layer. The early LEDs were discovered to emit very little infrared (IR) light. Convenient electrical components are available. Remote control circuits employ infrared LEDs, similar to those used in a broad variety of consumer gadgets. The original visible-light LEDs were low-intensity and confined to the colour red. Modern LEDs are available in the visible, ultraviolet (UV), and infrared spectrums.

2.2.2 Grow Light

The Russian botanist, Andrei Famintsyn, used artificial light for plant cultivation and study (1868). His dedication to photosynthesis and metabolism. He was the first to employ artificial light to cultivate and investigate plants (1868). Famintsyn proved that plant conversion and starch production may occur under artificial illumination. Definition Growth Light is an artificial light type used to stimulate plant development. Growing lights either strive to duplicate the sun's light spectrum or have a spectrum better suited to the demands of the plants being grown. Changing the growing light's hue, temperature, and spectrum emissions, as well as the lamp intensity, replicates outdoor circumstances. Certain spectrum ranges, luminous efficiency and colour temperature are ideal for usage in specific plants and periods based on the type of plant being cultivated, the stage of culture (e.g., germination/vegetative or flowering/fruiting phase) and the photoperiod required by the plants.

2.2.3 Color Spectrum of Sunlight

(Pavlis, 2017) , Plants are genetically wired to develop in the presence of white or yellowish-white light, which humans characterize as sunshine. This light seems white because it includes all of the colours of the rainbow, and when the colours of the rainbow are mixed, the result is the colour of white. A colour spectrum is a graphical depiction of all of the colours that may be seen while light is shining. In science, hues are referred to by wavelength numbers rather than names because it is a far more precise way of quantifying the colors. For example, the wavelength of a red colour might be 630 or 660 nanometers. Although both of these appear to be red to us, they are not.

When using fluorescent bulbs in a growing light, the hue of the bulb is referred to as cold white (which contains bluer) or warm white (which contains less blue) (which contains redder). However, although this was effective for fluorescent lights, it did not work as well for LED lights. When discussing LEDs, it is more appropriate to utilize wavelengths and represent the full colour spectrum rather than just the visible spectrum.

Color	Wavelength
violet	380–450 nm
blue	450–495 nm
green	495–570 nm
yellow	570–590 nm
orange	590–620 nm
red	620–750 nm

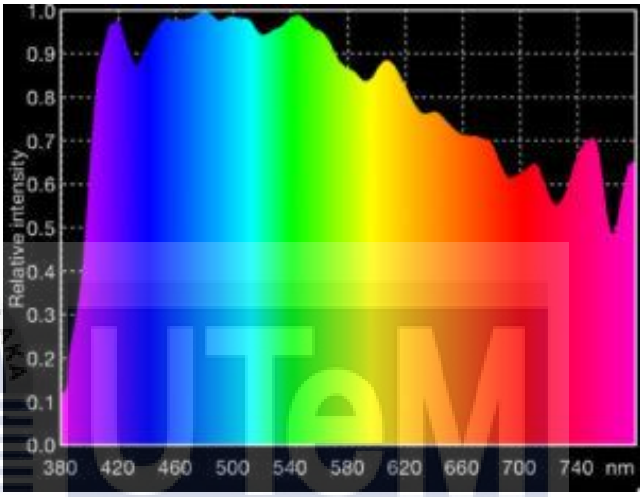


Figure 2.2: The color spectrum contains in sunlight

2.2.4 Theory to Choose Best Color Spectrum for Plants

Based (Pavlis, 2017) also, plants are mostly utilised for photosynthesis, which is accomplished via the use of light, and certain chemicals are produced in the leaves. Chlorophyll A and B are only a few examples of the most significant compounds in the environment. There are distinct spikes in the blue and red portions of the absorption spectrum (which measures how much light is absorbed), indicating that these colours will be used for photosynthesis. Almost no light is absorbed in the green wavelength band. Thus, the incorrect conclusion was reached that only blue and red lights are required by plants.

The idea that plants can thrive only on blue and red light is a fiction, according to science. The colour spectrum above illustrates what is happening with the plant leaf and is for chlorophyll that has been cleaned and placed in a test tube. In addition to other molecules like carotene and xanthophyll, photosynthesis is a far more complicated process. A colourful sample of the light absorbed by the complete leaf demonstrates that plants can utilise a range of wavelengths, including green. The hues of blue, red, and other hues, including green and yellow, are significant in photosynthesis because they constitute the majority of the light.

Because white light is produced by the sun and plants thrive when they get all of the hues of the spectrum, the best LED lights are those that create white light. The difficulty with this thinking is that plants do not require light that is white in appearance or light that is similar to the sun in appearance. Plants thrive under light that contains a lot of green and yellow, as well as red and blue in smaller amounts. It follows that white light is not vital for plants, since it is more vital to have the appropriate amount of each wavelength. It is a waste of energy to produce a large amount of white light in an attempt to wow us. The table below demonstrates that different colours have distinct functions in relation to plants.

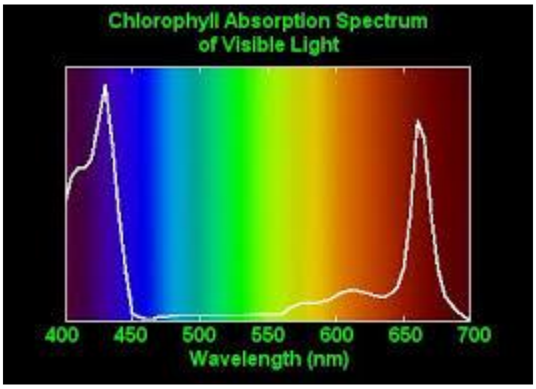


Figure 2.3: The blue and red light needed in Chlorophyll Absorption (Photosynthesis)

Colors of Lights	Function
Red Light	Essential for the growth of stems, as well as the expansion of leaves. This wavelength also regulates flowering, dormancy periods, and seed germination.
Blue Light	Needs to be carefully mixed with light in other spectra, since overexposure to light at this wavelength may stunt the growth of certain plant species. Light in the blue range also affects the chlorophyll content present in the plant as well as leaf thickness.
Green Light	Pull the stem as soon as possible. They don't have time to grow bigger, smaller, or lose weight. Only at the very top of society do the leaves appear. It also penetrates through thick top canopies to support the leaves in the lower canopy.
Far Red Light	It passes through the dense upper canopies to support the growth of leaves located lower on the plants. In addition, exposure to IR light reduces the time a plant needs to flower. Another benefit of far-red light is that plants exposed to this wavelength tend to produce larger leaves than those not exposed to light in this spectrum.
Yellow Light	On seedlings, there are no special effects. Because of the lack of lighting, high culture can be pulled easily. They have an undeveloped leaf inflammation.

Table 2.1: Function for growth plant based on type of light color

2.2.5 Relationship between Intensity of Light and Lumens

Photosynthesis is a chemical process that collects and converts light energy to sugar. These sugars are subsequently used as energy by the plant for a number of purposes. Light, carbon dioxide, and water are required for photosynthetic activity. Photosynthesis cannot occur if one of these elements is missing. When the level of light is increased, plants photosynthesize more. However, if the other two elements are too bright, they become restricted, and photosynthesis cannot increase any more. This might cause sunburn and harm to the leaves.

A Lumen (lm) is a measuring unit used to quantify visible light that can be seen with the naked eye. Lumens are units of measurement for the luminous flux of a certain light source. When purchasing plug-in lights for homes, it is feasible to observe that they represent lumen output. The greater the lumen output, the brighter or more intense the 'light source,' and the lower the lumen output, the brighter or more intense the light source. So, while light intensity is crucial, there is no need to rely on lumens to develop the plant. A light that mostly emits red and blue does not appear bright to humans, thus it has a low number of lumens. It seems bright and has a high lumen value to humans because the yellow-green light emits the same number of photons. However, this high-brightness light does not have an ideal colour spectrum for plant growth. Lumens are great for choosing a house light, but they are mainly worthless for choosing an LED light.

According to research (Feng *et al.*, 2019) The Influence of Light Intensity and Leaf Movement on Photosynthesis Characteristics and Carbon Balance of Soybean, "higher light improved the leaf structure and anatomy, which resulted in a significant increase in photosynthetic and chlorophyll florescence, particularly the quantum yield of PSII, which resulted in a significant increase in carbon balance."

2.2.6 Understanding on PAR and PPFD

The spectral spectrum (wave band) of solar energy from 400 to 700 nanometers that photosynthetic organisms may utilize in the process of photosynthesis is known as Photosynthetically Active Radiation, or PAR. This spectral region closely corresponds to the visible spectrum of light in the human eye. The spectrum range used for photosynthesis is depicted in the figure below.

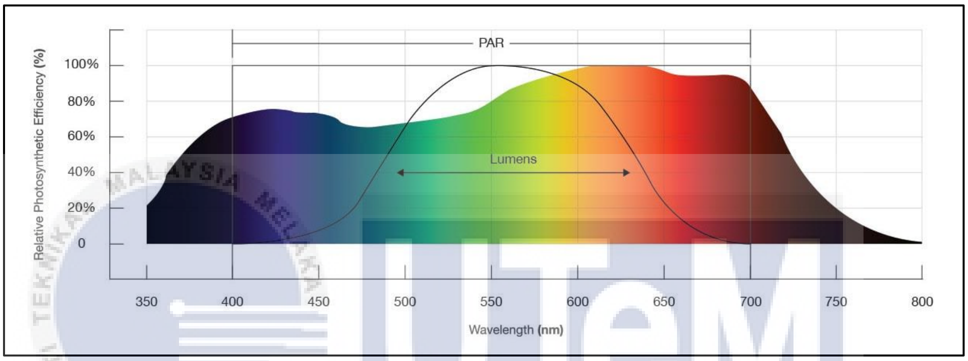


Figure 2.4: Wavelength at PAR

Millimoles of light energy per square metre of photosynthetically active radiation is the unit of PAR. Plant development and photosynthesis need photosynthetically active sunlight. Increased PAR promotes plant development. It's critical to monitor it to ensure the plants get adequate light. PAR is expressed in millimoles per square metre and varies between zero and three thousand millimoles per square metre. At night, the PAR is zero. At noon in the summer, PAR levels may reach 2,000 to 3,000 millimoles per square metre.

The photosynthetic photon flux density is denoted by PPFD. PPFD quantifies the quantity of PAR that reaches the plant directly, or, as a scientist could put it, "the number of photosynthetically active photons that fall on a particular surface per second." The PPFD of a specific point on your plant canopy is measured in micromoles per square metre per second (mol/m2/s).

Both PPF and PPFD are abbreviations for the quantity of light emitted by a source of light or a patch of light. PPF and PPFD are used to determine the quantity of such photons. The critical difference is that PPFD calculates the density of photons colliding with a particular surface, while PPF calculates the overall number of photons released by a light source. The figure below illustrates the distinction between PAR and PPFD.

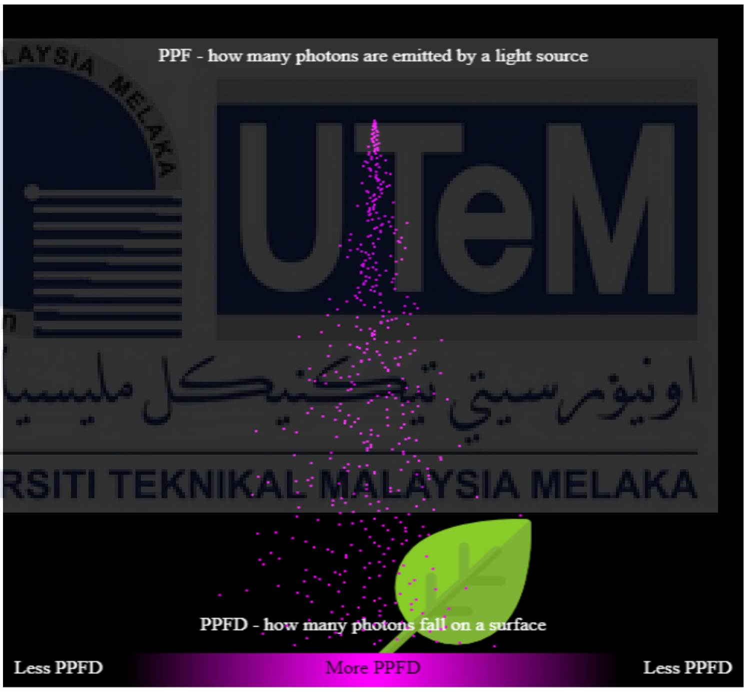


Figure 2.5: Relationship between PPF and PPFD

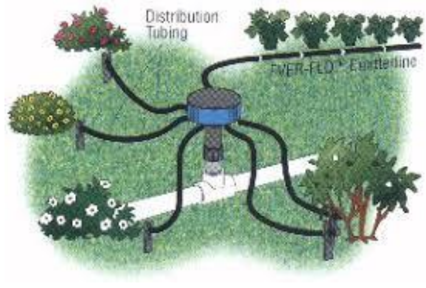
2.3 Technology in Irrigation System

Irrigation is the process of preparing the ground for agriculture by watering it. It is the process of applying water to crops via artificial channels in order to aid in their growth. Water is essential for the development of plants. Plants and crops cannot thrive without some form of water. As a result, it is critical to supply water to crops and plants when they are in need. Water is acquired in a number of ways by plants. Wells, ponds, lakes, canals, dams, and reservoirs are just a few examples.

Irrigation is crucial for agriculture and agriculture. To begin, photosynthesis helps plants to grow and photosynthesize. Plants receive minerals and nutrients from the soil via their roots. These minerals dissolve in the water of the soil. Then, the nutrients are delivered throughout the plant by the water. Thus, photosynthesis and growth are achievable. Second, it gives the moisture that the plant requires during the germination period of its life cycle. Thirdly, by delivering moisture to the soil, it helps to enhance its fertility. Additionally, it enables land plugs. Finally, the farm's production is enhanced.

Historically, conventional irrigation was used. Some small farms in rural areas, however, continue to employ them. They're cheaper than modern alternatives, but less efficient. Because human or animal effort powers them. They include Moat, Chain Pump, Dhekli, and Rahat. Modern irrigation methods, on the other hand, rely on cloud-based, timed sprinkler systems, drip irrigation, and groundwater pipelines. This can lead to the formulation of personalized irrigation plans that preserve landscape health by irrigating only when necessary, based on regular, site-specific runtime changes and accurate, high-resolution ET Everywhere weather data.

Traditional



Modern

Figure 2.6: Comparison irrigation technology

2.3.1 Auto Irrigation by Soil Moisture Sensor

Moisture measurement is critical for agricultural applications because it enables farmers to control their irrigation systems more efficiently. Knowing the precise soil moisture conditions in their fields enables farmers to not only use less water to grow a crop, but also to boost yields and crop quality through enhanced soil moisture management throughout important plant growth phases. The soil moisture sensor is one type of sensor used to assess the volumetric content of water in the soil. Due to the elimination of the direct gravimetric dimension of soil moisture, drying and sample weighing are required. These sensors indirectly determine the volumetric water content of the soil by utilizing other soil laws such as the dielectric constant, electrical resistance, or neutron interaction and moisture content replacement.

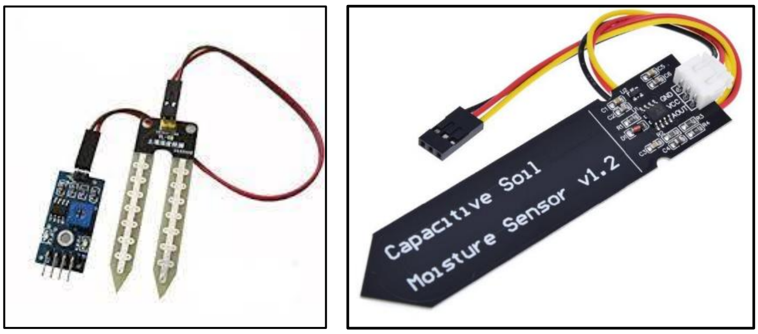


Figure 2.7: Soil Moisture Sensor

According to the operating described in (Geetha *et al.*, 2020), the Soil Moisture Sensor measures the dielectric permittivity of the surrounding medium via capacitance. The dielectric permittivity of the soil is a consequence of its moisture content. The sensor generates a voltage proportional to the dielectric permittivity of the soil, and hence to its water content. The sensor takes an average of the water content over its whole length. There is a 2 cm zone of effect relative to the sensor's flat surface, but it is insensitive or non-existent at the sensor's extreme edges. The Soil Moisture Sensor operates in a fairly straightforward manner. It operates on the voltage comparison concept. The following circuit will assist you in comprehending how a conventional soil moisture sensor operates.

2.3.2 Automatic Soil Moisture Monitoring System

For fast development, it is essential to keep an eye on plant health. People in today's busy society sometimes forget to care for their plants, resulting in poor plant development and health. It is crucial that plants are properly grown in order to ensure their full growth. The automated plant monitoring unit has recently generated a lot of interest because of its prospective applicability to new technologies. This approach is used more particularly to increase the efficiency of current approaches for plant development or to build and design new. The plant monitoring gadget is useful for watering the plants and for monitoring some critical parameters for plant propagation.

A number of factors influenced the plant's rapid development. Among them are humidity, temperature, sunlight, humidity and other factors. In general, the plant requires a favourable atmosphere for maximum functioning. With intelligent irrigation, just roughly 20 per cent of the usual water utilised may be utilised to complete the full irrigation process. As a result, we need a smart irrigation system that saves 80 percent of the current lost water to minimise the huge quantity of water consumed in irrigation. Furthermore, every plant requires the correct quantity of light and temperature to grow. If the temperature is too high, the plant will dry out and unwieldly spread and blossom if the temperature is too low. The mechanism of photosynthesis is damaged if there is inadequate sunshine.

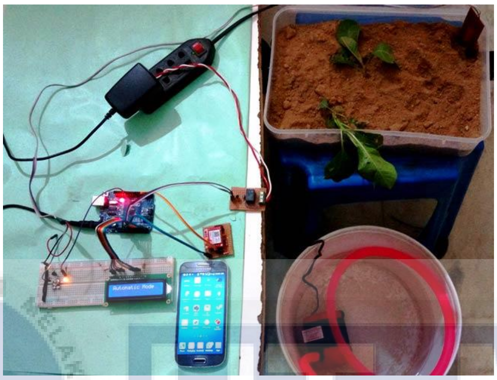


Figure 2.8: Example of Monitoring System to Plant

2.4 Humidity for Growth Plant

According to (YAN *et al.*, 2010), Researchers conducted a series of field and plant growth chamber studies in 2006 and 2007 to determine how relative humidity (RH), genotypes, and nitrogen delivery rates impact organ temperatures and spikelet fertility rates in rice. Temperature, relative humidity, genotype, and nitrogen delivery rate were shown to affect organ temperatures. HR rises with constant air temperature, and air temperature rises with constant RH, both of which considerably raise organ temperature. There were also variances in organ temperatures between cultivars; in similar climes, cultivars with upright panicles had lower organ temperatures than cultivars with drooping panicles. Similarly, as compared to plants with panicles below the panicle, cultivars with panicles above the flag leaf exhibited lower panicle temperatures. Panicle temperature was also shown to be strongly inversely related to grain filling and seed setting rates. Spikelet fertility may be retained in a high temperature environment by lowering the spikelet temperature to a lower RH. The pace at which panicle fertilizer was applied had a significant influence on the temperature of the organ and canopy. In general, the canopy temperature of rice with a plentiful supply of nitrogen was lower than the canopy temperature of a nitrogen-deficient treatment.

(Shamshiri *et al.*, 2018), The greenhouse's total moisture is caused by condensation on the cover, vapor loss via ventilation, and the balance of plant transpiration and evapotranspiration. In science, it is represented as absolute humidity (g m-3), specific humidity (g water kg-1 air), or relative humidity (%), but the latter is more commonly used. According to the ASABE guidelines, a relative humidity range of 60% to 90% is adequate for most greenhouse tomato types (2015). Furthermore, it is advised that the ideal range of relative humidity during all phases of tomato growth is 50-70 percent. Tomato pollination is also greatly boosted when the RH is about 60%, according to studies. Plants exposed to greater temperatures demand more humidity. It should be highlighted. This has to deal with the plant's transpiration. Thus, transpiration on the leaf surface is ineffective in greenhouse settings when the air surrounding the plant is too hot and damp, the leaves are too hot and moist, and the root and stem system is unable to give appropriate water to the leaves. As a result, cooling is required to alleviate these tensions. Because the salinity is lower and the condensation is higher in cold-climate locations, the HR is often low.

2.4.1 Application Arduino Control Humidity and Temperature

People may now increase the quality of their employment, hobbies, lives and other activities by introducing technology with basic electrical components into our tools and equipment. Adding artificial intelligence to things we care about is incredibly tempting and remarkable. Some may be familiar with smart gardens, using smart management and supervision of plants, flowers, and other items. As a strategy for this project, Arduino will employ time and the quantity of water delivered to plants, as well as lighting, temperature, and a range of other important characteristics. This data may be utilized to keep the plant in excellent functioning order.

By (Kalaiarasi *et al.*, 2018), The typical analogue humidity sensor must be developed for the signal circuit, adjusted and calibrated, and linearity, repetitiveness, interchange, and consistency cannot be guaranteed for accuracy. DHT11 and DHT22 are new temperature/humidity sensors from Sensirion that combine a CMOS chip with Sensor. CMOSens technology. A temperature and moisture sensor, signal amplifier, A/D switch, and a 12 C bus interface are all interloaded on the device.

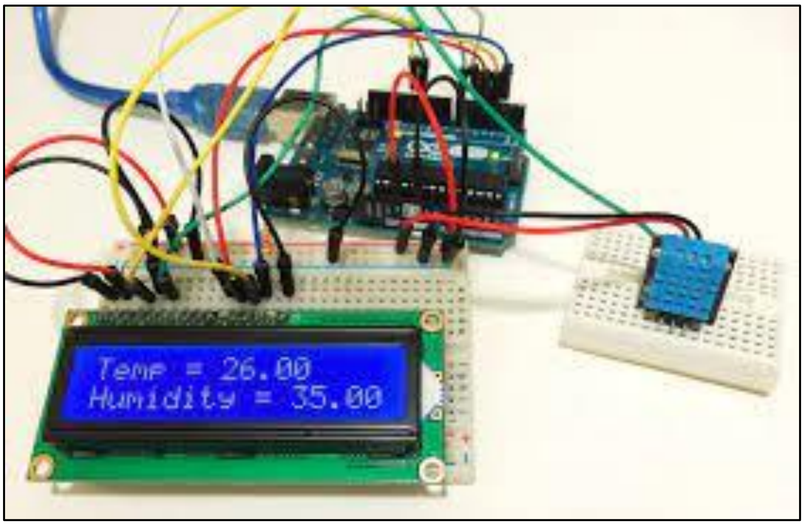


Figure 2.9: Humidity Sensor Interface with Arduino microcontroller

2.5 Solar Energy as Supplier to Agriculture System

Solar energy and solar radiation may create heat, chemical processes or create electricity. The total number of solar energy incidents on Earth far exceeds current and projected global energy consumption. Where appropriate, this well-dispersed source can supply all future energy requirements. In the contemporary period, the endless supply of solar energy and its non-polluting quality, in sharp contrast to the finite fossil fuels of coal, oil and natural gas, are predicted to attract renewable energy sources.

Based on (Chel, 2010), Renewable energies are an important part of directing our energy system toward long-term sustainability and supply security. The use of renewable energy sources to create power, heat, or biofuels has risen to the top of national and international energy policy agendas. At the European level, for example, the goal of meeting 20% of total energy consumption from renewable energy sources by 2020 has set lofty targets for these "new" energy supply options to meet our needs. Solar energy is a renewable energy source that is widely employed in agriculture for a wide range of applications. Besides (Chel, 2010) also, Farmers are encouraged to use solar power and are given the important opportunity to network and sell extra energy generated at a subsidised price in developing nations with limited water and fertile land. Solar Energy Farming (SEF) with a Power Purchase Agreement (PPA) result in inefficient and wasteful solar energy utilisation at the expense of potential. Surplus energy can also be used for other profitable on-farm applications such as heating, chilling, drying, grinding, and distribution. In sensitive areas, energy consumption may either restrict agricultural activity or boost water efficiency.

Farmers are encouraged to utilise solar power and have valuable network capacity and sell extra electricity at a subsidised price in developing nations with high water and arable land. Solar Energy Farming (SEF) with Power Purchase Agreement (PPA) provides inefficient and wasteful use of solar energy at an opportunity cost. Other beneficial on-farm applications, including heating, cooling, drying, grinding and distribution, can also be done with excess energy. Energy consumption in susceptible places can diminish or boost water efficiency.

2.5.1 Application Solar Panel

(Fuada *et al.*, 2015) A solar cell is a device that converts solar energy into electrical energy through the process of photosynthesis. The output of the solar cell continues to be in the form of direct current voltage (DC). The use of this solar cell has a number of advantages in Indonesia, including the fact that the energy it generates is free, that maintenance is simple and straightforward, that there are no moving parts because spare parts and lubrication are not required, that the equipment operates silently and has no negative impact on the environment, and that it can be programmed to operate automatically. When implementing a solar energy system, it is necessary to take into account power requirements such as the amount of electricity consumed, the number of solar panels installed, and the number of batteries installed. It is defined by the quantity of electricity required to recharge the battery. The electric motor must also be operated at the right voltage and power, among other things. The objectives of this photovoltaic research are to understand the performance of photovoltaic units in comparison to existing data from the manufacturer (for data comparison), to understand the voltage and current that come from the solar panel towards the charge, and to understand the current, voltage, and power that come from the solar panel, and to finally know the performance of solar panels.

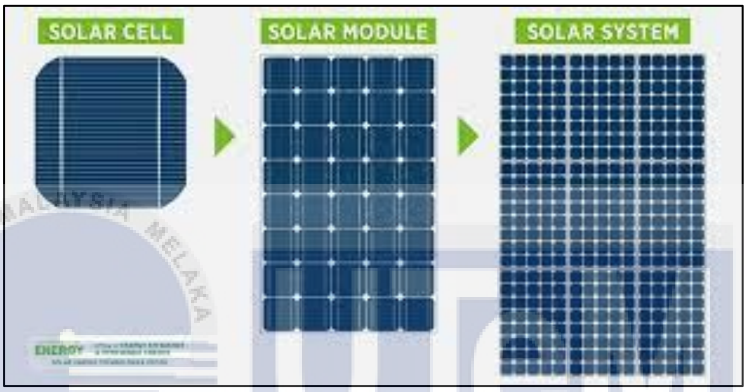


Figure 2.10: Solar Structure

2.6 Chapter Summary

This chapter describes some ways and concepts to use a smart cropping system as a future reference, especially the methodology chapter. The highlights of this literature review are divided into three, namely the concept of crop light, sensor-using irrigation systems, and the use of solar energy as the main source to power this project's system. The description of the type and way light feeds plants that use the photosynthesis process is highlighted because the purpose of this project is to replace the sunlight source with LED light. So, based on scientific studies, most types of red and blue light combinations make the tree easy to grow but also depend on the type of plant to be cared for. This is because, compared to yellow and green, sunlight on blue and red is very high. Planning for combining red and blue LED lights will also be highlighted.

Next literature review on crop irrigation systems. To keep the plants moist or watered, the watering system should be used automatically. Most soil moisture sensors are used for smart planting projects. This is because the soil moisture sensor can regulate and monitor the soil status so that it is always moist without excessive water, compared to the time-based irrigation system. According to the schedule, the watering system is not said to be unsystematic but, in my opinion, it does not guarantee moisture in the soil and, if in a rainy situation, the watering system also works according to time, so water wastage occurs.

Finally, the use of sunlight for conversion purposes was also studied. Although the crops are well cared for by providing light and water with electrical and electronic technology arrangements, the energy source used to operate this smart planting system must also be looked at. Whereas the cost of electricity for smart plants or components is frequently associated with humans. This project will be planned to use solar panels to save electricity costs on this plant system, such as the water, light and temperature control components.

CHAPTER 3

METHODOLOGY

3.0 Introduction

In this chapter, we will cover the implementation method to build this smart garden system where it is divided into four parts of the system, namely LED growth light system, watering design based on soil moisture sensor, cooling system based on temperature and humidity and lastly solar system. This system will be connected to the Arduino appliance for the purpose of control interface and monitoring of the entire smart garden system.

3.1 Software Development

The Arduino IDE software will be used to control and monitor the smart garden system, and code will be written to programmed the hardware as part of the control and monitoring process. In addition, Proteus software is used for testing purposes prior to the actual implementation of the hardware by the manufacturer. This test can be used to see how the system is moved, as well as to analyses the input and output data.

3.1.1 Arduino IDE

For Windows, macOS, and Linux, the Arduino Integrated Development Environment (IDE) is a cross-platform framework developed using C and C++ functions. It is used to create and upload programmed to Arduino-compatible boards as well as other development boards from third-party suppliers. To support the C and C++ programming languages, the Arduino IDE makes use of unique code organization principles. The Arduino IDE includes a software library called Wiring that implements a variety of popular entrance and exit operations. The Arduino IDE uses software to convert an executable code to a hexadecimal-encoded text file that is then loaded into the Arduino board's firmware through a loader application.

3.2 Design Specification of LED Growth Light

Photo production, metabolism, morphogenesis, gene expression and other physiological reactions in plants are regulated by light, making it one of the major growths and development variables. Biomass accumulation, flowering time, elongation of the stem and nutritional quality may be modified by modifying light wavelength, photon flow (light quantity) and photoperiod. So, when choosing the LED type, you must locate the proper wavelength, because the wavelengths emitted are crucial while shopping for the LED. An LED light marketed for a store (for human light) was created to perform effectively for the eyesight of humans, not in order to accentuate the blues and reds, which necessarily contain the entire PAR spectrum.

3.2.1 Design of LED circuit using MOSFET

This design circuit is simply an overview of describing how to light up the high-power LED using MOSFET. This system will be using 5V voltage to operate. There are four different kinds of LED lights, which are blue, red, ultraviolet, and white, each with its own spectral light. The related spectrum is blue wavelengths are 460nm, red wavelengths are 660nm, full white wavelengths are 840nm, and ultraviolet wavelengths are 410nm. Watt power for LED will be 3W and current use around 0.6 to 0.7 mA.

3.2.2 MOSFET as Switch and fixing the LED power

MOSFET (Metal Oxide Semiconductor Field Effect Transistor) transistors are a type of semiconductor device that are commonly utilized in electronic devices for switching and amplifying electronic signals. The operation of a MOSFET is dependent on the metal oxide capacitor (MOS), which is the MOSFET's primary component. Between the source and drain terminals is an oxide layer. It can be switched between p- and n-types by applying positive or negative gate voltages. When a positive gate voltage is applied, the holes beneath the oxide layer are repelled and are pushed downward through the substrate. The region of deflection occupied by bonded negative charges associated with acceptor atoms. It is protected from the channel by a thin coating of metal oxide. In this circuit, an N-channel MOSFET is utilized in enhanced mode to switch the bulb ON and OFF. When a positive voltage is provided to the gate of the MOSFET, the light is turned on (VGS =+v), or when the device is turned off (VGS=0).

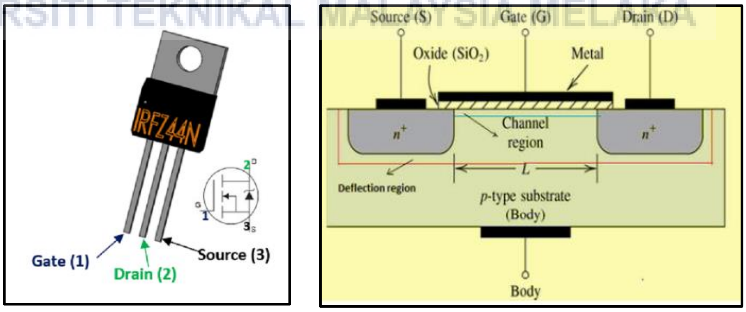


Figure 3.1: MOSFET component and its block diagram

3.3 Design Specification of Auto Irrigation using Soil Moisture Sensor

According to a project (HASSAN *et al.*, 2019), an inexpensive automatic irrigation system is based on the Arduino microcontroller that can be utilized on a farm or in a typical residential garden. Using the Arduino as the central core, the suggested system is designed to automatically water the plants when the soil moisture sensor detects water deficiency in the soil.

3.3.1 Block Diagram of Auto Irrigation circuit

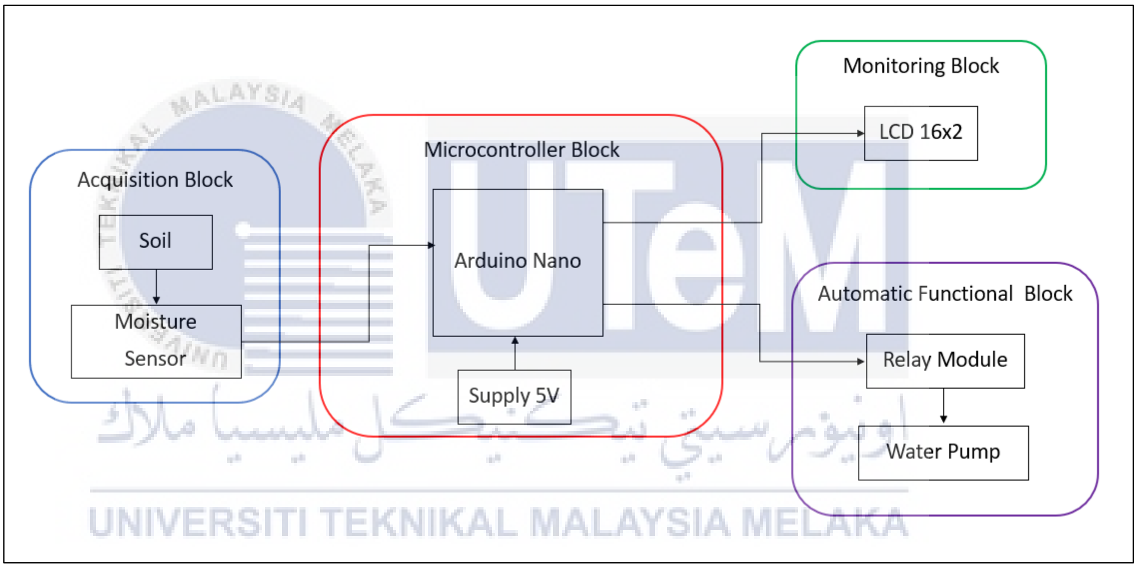


Figure 3.2: Block diagram of Auto Irrigation interface

According to the block diagram above, four sections must be considered. To begin, the acquisition block is comprised of a single soil moisture sensor for data collection from the soil. The moisture content of the soil dictates whether a high or low voltage is sent to the microcontroller to indicate whether the soil is wet or dry. When wet, the soil transmits a low output voltage; when dry, it transmits a high output voltage. This sensor is connected directly to the Arduino microcontroller via a shielded wire. Following that, the microcontroller block will serve as the primary piece of hardware for the project. It receives input from the soil moisture sensor and processes it according to the microcontroller's specifications. To operate, the Arduino requires power. Following that, there are two sections of the output: the monitoring block and the automatic functional block. Two primary pieces of hardware are used to control the automated function: a relay module and a direct current watering pump. A relay is a self-contained electric switch that automatically switches from OFF to ON or vice versa via an electromagnet. The switch regulates the electrical current flowing through the water pump. When the moisture level in the air falls below a predetermined level, the Arduino sends a signal to the relay module, which opens the path for electricity to flow through the water pump and water the plant. When the system detects an appropriate level of water in the soil, the relay closes the electric path, effectively shutting down the water pump. The LCD will display readings such as moisture level in percentage and water pump status for monitoring purposes.

3.3.2 Flowchart of Auto Irrigation program

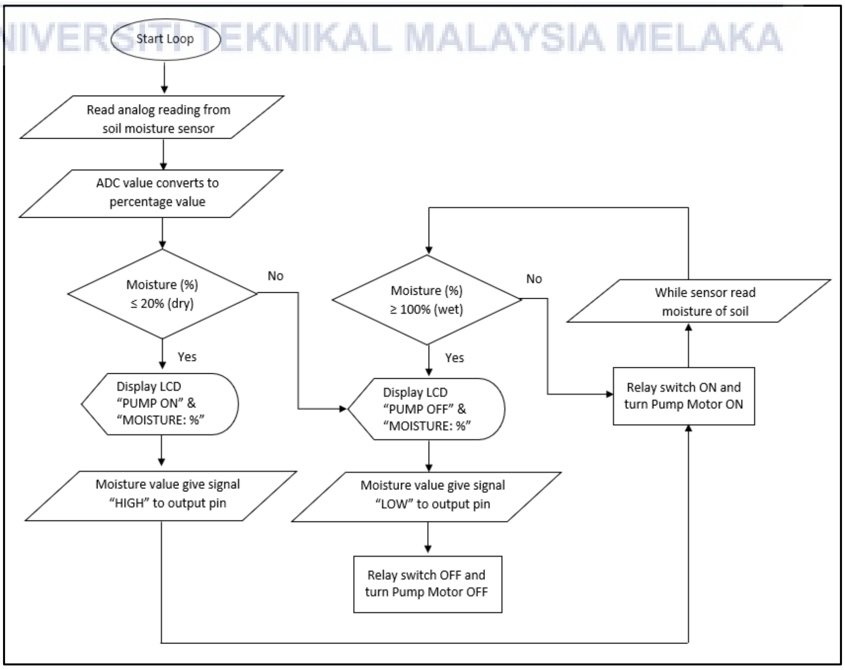


Figure 3.3: Flowchart of auto irrigation program

3.3.3 Capacitance Soil Moisture Sensor Work Principle

The Capacitive Soil Moisture Sensor Module estimates the quantity of moisture in the soil by sensing variations in capacitance. This might be used in an automatic plant watering system or to trigger some sort of alarm when a plant needs to be watered. The main disadvantage of the popular fork-type resistance sensor is that the probes placed into the soil must be made of conductive bare metal, and the modest electrical current that runs between them causes the probes to corrode over time due to electrolysis. Because the sensor metal injected into the soil can be covered in solder resist to limit corrosion and electrical current is not flowing through the soil to generate electrolysis, the capacitive probe improves the situation. A peak voltage detector turns the waveform from the TL555I into a DC voltage that may be read by a microcontroller's ADC input in principle. Moisture affects the capacitance of the circuit, which changes the peak amplitude of the signal and thus the DC voltage output measured by the MCU. Lower DC voltage output equals higher moisture.

Figure 3.4: Capacitance Soil Moisture Sensor

3.3.4 Calibration for System Testing

It is recommended that users calibrate their soil moisture sensors for the kind of soil that they plan to monitor in order to get trustworthy results from their sensors. Different kinds of soil might have an impact on the sensor's performance. As a result, depending on the kind of soil utilized, the user's sensor may be more or less sensitive. Before beginning to save data or initiating activities, users should double-check the sensor's actual values. The table below serves as an example of how to configure system settings (HASSAN *et al.*, 2019).

Test	Soil Moisture Sensor
Test Purpose	To test the sensor values and its functionality
Test Environment	A glass of water and Arduino IDE.
Expected Step	Step1: Implement code to determine the moisture level of the soil with Arduino IDE Step2: Open the serial monitor in Arduino IDE and see the measure sensor value for the dry condition. Step3: Immersed the soil moisture sensor into a glass of water and see for the wet condition in the serial monitor in Arduino IDE too.
Expected Result	The soil moisture sensor is light up in the controller when it is switched on, and it can show the lower and upper boundaries of the sensor value in dry and wet conditions.

Table 3.1: Step to calibrate soil moisture sensor

3.4 Design Specification of Temperature and Humidity Sensor

The temperature is a measure of heat in general, whereas humidity is a measure of water vapor in the air. Another specification for humidity is the temperature and pressure of the system. With increasing air temperatures, the air can store more water molecules and their relative moisture drops. Relative humidity rises as temperatures fall. When the atmospheric temperature is near the dew point value, there is high relative humidity in the air. Therefore, the temperature directly refers to the quantity of humidity the atmosphere can store. The goal is to acquire the optimal humidity for the plant. The recommended moisture range is RH 40% to 70% (relative moisture) with a 50% optimum. Plants cannot properly transpire or breathe if the environment becomes too wet. Very damp air is also good for the development of powdery mildew and unpleasant fungi. However, an oscillating fan is a simple and economical alternative. Air movement supports moldy and fungal prevention and encourages air exchange.

3.4.1 Block Diagram of Temperature and Humidity system

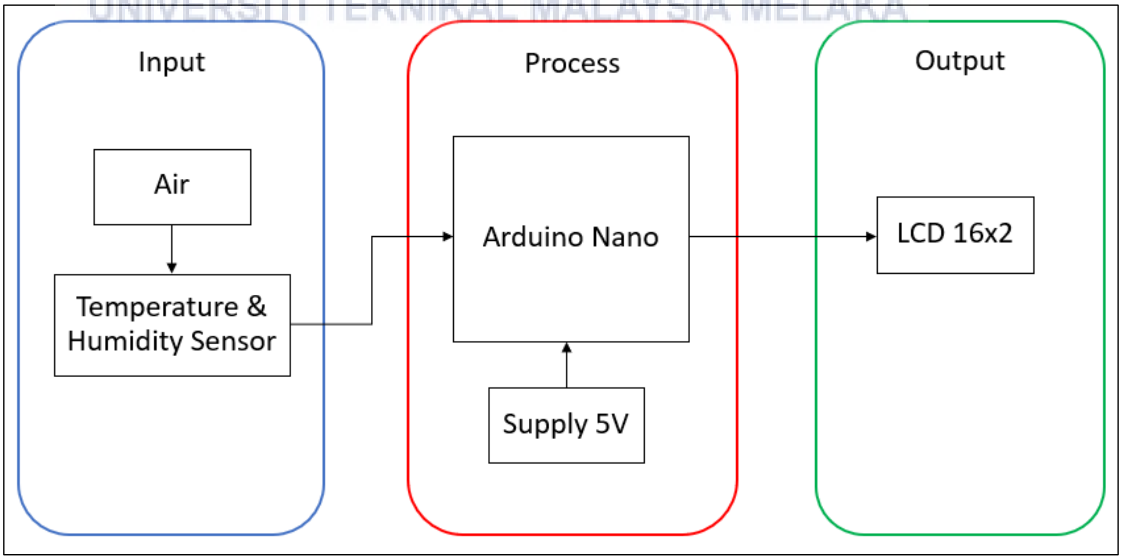


Figure 3.5: Block diagram of monitoring ventilation based on Temperature and Humidity Sensor

According to the block diagram above (figure 3.6), a DHT11 temperature and humidity sensor is first generated by the input and then collects data from the current air. The current air determines whether a high or a low voltage is to be sent to the microcontroller to decide whether the air decreases or increases. This sensor is directly connected to the Arduino microcontroller. After that, the Arduino's microcontroller will operate as the core hardware of the project. It accepts DHT11 input and processes it according to the microcontroller specifications. For it to work, an Arduino must be provided. Next to the output is an LCD monitor which displays the temperature and moisture status. There is an additional option that can be done on this system, which is a DC fan. The DC function of the fan can control the comfortable ventilation of the plant. This fan can be combined on an Arduino and will work via the temperature setting detected by the DHT11 device. However, if the planting area is in a dim area, it is best not to add a DC fan to reduce battery power consumption.

3.4.2 DHT11 Temperature and Humidity Sensor Work Principle

A humidity measurement component, an NTC temperature sensor (or thermistor), and an IC are located on the sensor's back side. These sensors, however, use an NTC temperature sensor or thermistor to measure the temperature. A thermistor is a changeable resistor in reaction to temperature fluctuations. To offer greater resistance to fluctuations in modest temperature changes, these sensors are manufactured by sintering semiconductive materials such as ceramics or polymers. The name "NTC" stands for "Negative Temperature Coefficient," meaning reduced resistance as the temperature increases. Below is the DHT11 component structure (Figure 3.9).

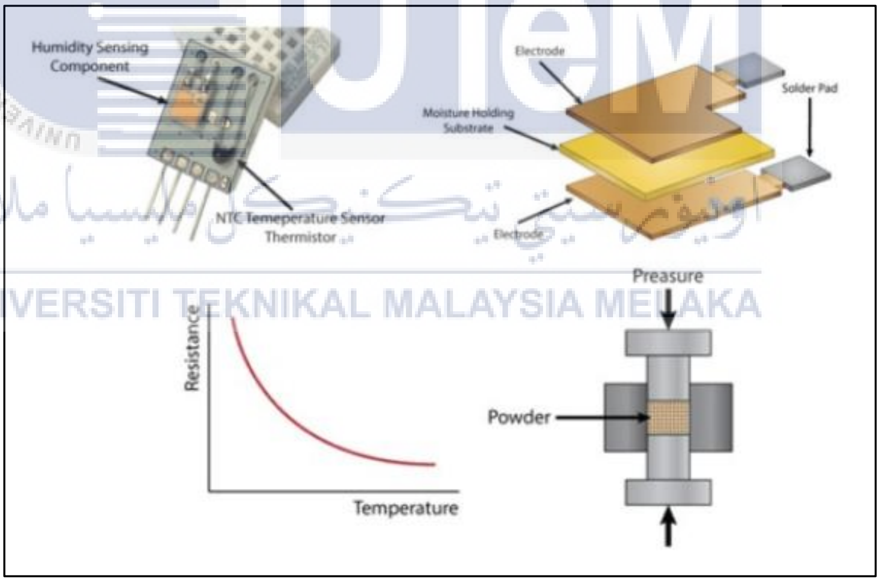


Figure 3.6: DHT11 component structure

3.5 Design Specification of Micro SD Card Module for Data Logging

Data storage is one of the most crucial aspects of any project. Depending on the type and size of the data, there are numerous methods for storing it. SD and microSD cards are among the most practical storage devices, being used in devices such as mobile phones, minicomputers, and others. Because this project does not include data recording through the internet, the SD card module is especially beneficial for projects that require data logging and therefore do not require an internet connection. To put it simply, the SD and microSD card modules allow you to interface with the memory card and write or read the information on it. The module interfaces with the SPI protocol. To utilize these modules with Arduino, we'll need the SD library. This library is pre-installed on the Arduino application by default.

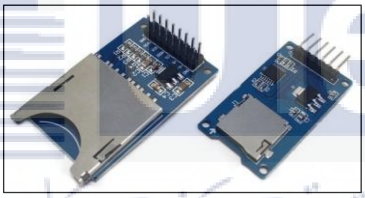


Figure 3.7: SD and micro-SD module

3.5.1 Block Diagram of Data Logging System

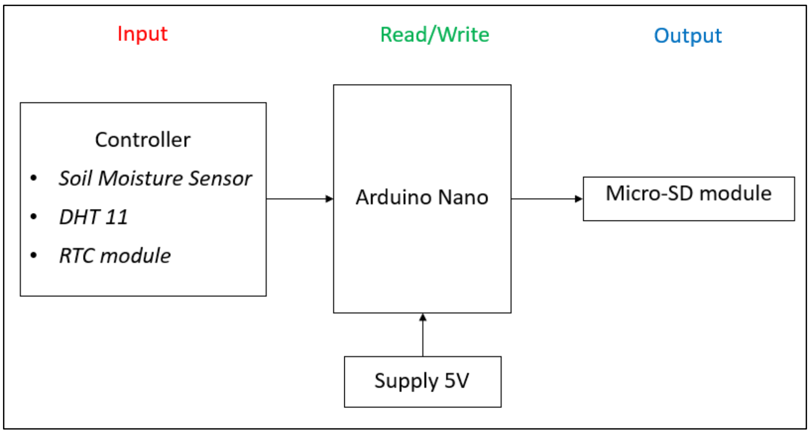


Figure 3.8: Data logging using micro-SD module with Arduino interface

As a simple procedure, three types of parameters will be recorded into a micro-SD module using an Arduino interface in format text file. Those are the percentage of soil moisture, air temperature and humidity, and the time clock. This information will be needed to monitor the system's efficiency in terms of plant health.

3.6 Design Specification of Real Time Clock

Without a real-time clock, this project will not be completed. A real-time clock is required in order to determine the exact condition at the time of the incident and to perform an analysis based on that information. So, there are several methods for recording or displaying time clocks, and one of them is using a module. The time clock may be defined without the module, which is based on the real-time of the internet system, but because this project does not have an online connection, the module was chosen. The module is RTC DS1302. A real-time clock/calendar and 31 bytes of static RAM are included in the DS1302 trickle-charge timekeeping chip. It uses a basic serial interface to connect with a CPU. The real-time clock and calendar display information in seconds, minutes, hours, days, dates, months, and years. For months with fewer than 31 days, the end of the month date is automatically modified, including leap year corrections. The clock has an AM/PM indication and works in either a 24-hour or 12-hour mode. Using a synchronous serial connection to connect the DS1302 to a microprocessor simplifies the operation. To connect to the clock/RAM, just three wires are required: CE, I/O (data line), and SCLK (serial clock). Data can be sent one byte at a time or in bursts of up to 31 bytes to and from the clock/RAM. The DS1302 is designed to run on very low power and maintain data and clock information with less than 1W of power consumption.

Figure 3.9: RTC DS1302 module

3.7 Design Specification of Solar Panel as Power Supply Source

According to (Chel, 2010), Solar cells use the photovoltaic effect to convert sunlight to direct current electricity. Solar cells in a photovoltaic module are made of semiconductor materials. When light energy strikes a cell, electrons are pushed free from the material's atoms. Electrons are captured in the form of a direct current using electrical wires connected to the substance's positive and negative sides. The energy generated may then be utilized to power a load such as a water pump or stored in a battery. Due to the fact that solar modules produce power only when the sun is shining, systems that operate at night need some kind of energy storage.

3.7.1 Block Diagram of Solar System

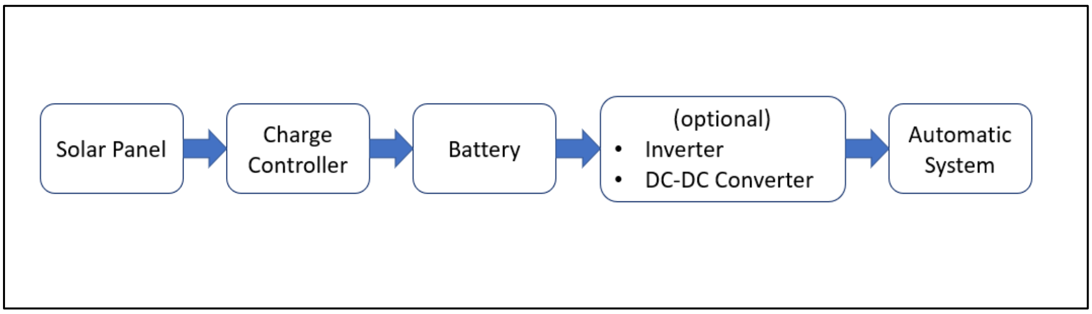


Figure 3.10: Block diagram of solar system

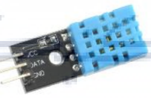
A block diagram (Figure 3.10) may be described above. First, sunlight will offer the solar panel energy to converse with electrical energy. Then the charging control uses energy conversion to control the charging batteries from the solar panel. If the load controller is coupled to the battery, the battery may safely store electricity from solar power without overflowing. After a battery has adequate voltage, it may directly enter the optional device that is the inverter or DC-DC converter into an automated system or. An inverter may convert DC to alternating current (AC) if the user needs to provide the AC load component. Meanwhile, the buck converter is a common DC-DC converter that effectively converts a high voltage to a low voltage. Efficient power conversion enhances the battery life, decreases heat and enables the construction of smaller electronics.

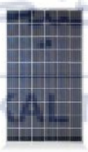
3.7.2 Solar Charger Controller Work Principle

(Osaretin, 2016), A charge controller, sometimes referred to as a charge regulator, is a voltage and/or current regulator that protects batteries from overcharging. It regulates the voltage and current flowing between the solar panels and the battery. Because the majority of "12 volt" panels output about 16 to 20 volts, if there is no control, the batteries will be destroyed by overcharging. There is a reason why panels are not created only to generate 12 volts; the panels will generate electricity only when it is cold, in optimal circumstances, and in full sunshine. You cannot rely on this in the majority of locations. The panels must provide some additional voltage to ensure that, even when the sun is low in the sky, there is still some output from the panel even in the presence of dense haze, cloud cover, or high temperatures. The panel must supply at least 12.7 volts in the worst-case circumstances. The primary function of a charge controller is to maintain the battery at the greatest feasible charge level. To avoid a deep discharge, the charge controller prevents overcharging the battery and disconnects the load. Charge controllers should theoretically be able to directly regulate the battery's state. Between pulses, the controller checks and changes the battery's level of charge. This approach successfully "tapers" the current, producing a result akin to "constant voltage" charging. Without charge control, the current from the photovoltaic module flows according to the irradiance into a battery, regardless of whether the battery requires charging. Unregulated charging results in substantial gassing, electrolyte loss, internal heating, and increased grid corrosion when the battery is completely charged. As a consequence, the charge controller protects and extends the battery's life.

Figure 3.11: Solar Charger Controller

3.8 Tool and Components requirement for Full System

Components	Picture	Function	Unit
LED 3W Royal Blue (450nm) 3W Deep Red (660nm) 3W Far Red (720nm) 3W Green (520nm)		To emit the light.	2 x 4
MOSFET (IRL2203N)		To control voltage/current flow between the source and the drain.	4
Capacitance Soil Moisture Sensor		To measure the water content of soil (by measuring the dielectric permittivity of the soil, which is a function of the water content)	1
12V/5V DC motor pump		DC Powered Pumps use direct current from motor or solar power to move fluid in a variety of ways.	1
DHT11 Temperature & Humidity Sensor		To measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed).	1
Micro-SD module		To transferring data to and from a standard SD card.	1
Micro-SD		To storing data	1
RTC DS1302		To provides information about second, minute, hour, day, week, month, and year.	1
I2C LCD		To display the character or words	1

Relay module		Electrically operated switch that can be turned on or off deciding to let current flow through or not.	1
Wire		To conduct electricity.	few
Potentiometer (10k Ω) (optional)		It functions as a voltage divider, producing a voltage output signal with a continuously variable voltage.	1
12V DC Power Supply		To give power to an operation circuit or components.	1
Aluminum Heatsink		To reduce the heat generated by the components attached to it.	8
Thermal Adhesive		To conduct and transfer heat between two areas. This is a stick that is sandwiched between an LED and an aluminum heatsink.	1
Solar Panel		A collection of solar (or photovoltaic) cells, which can be used to generate electricity through photovoltaic effect.	1
Solar Charger Controller		To regulates the voltage and current coming from the solar panels going to the battery.	1
DC-DC Step Down Converter		To steps down voltage (while drawing less average current) from its input (supply) to its output (load).	2
Push Button		Simple switch mechanism to control some aspect of a machine or a process	1
Resistor 220Ω		To reduce current flow	1

Breadboard		To build and test circuits quickly before finalizing any circuit design.	1
ON/OFF Switch		To toggles the power	1
1meter Host		To flow the water	1
T-Pneumatic connector (*Two-way output*)		To connect between host	3
Container		To place the plant	4

Table 3.2: Materials needed for implement full smart garden system

3.9 Full circuit design of Smart Garden System

The circuit below was separated into three circuits to make it easy to view and understand the connection between them. Circuit 1 represents the circuit that interfaces with Arduino, while Circuit 2 represents the LED system using MOSFET. The last circuit represents the solar system to power up circuit 1 and circuit 2.

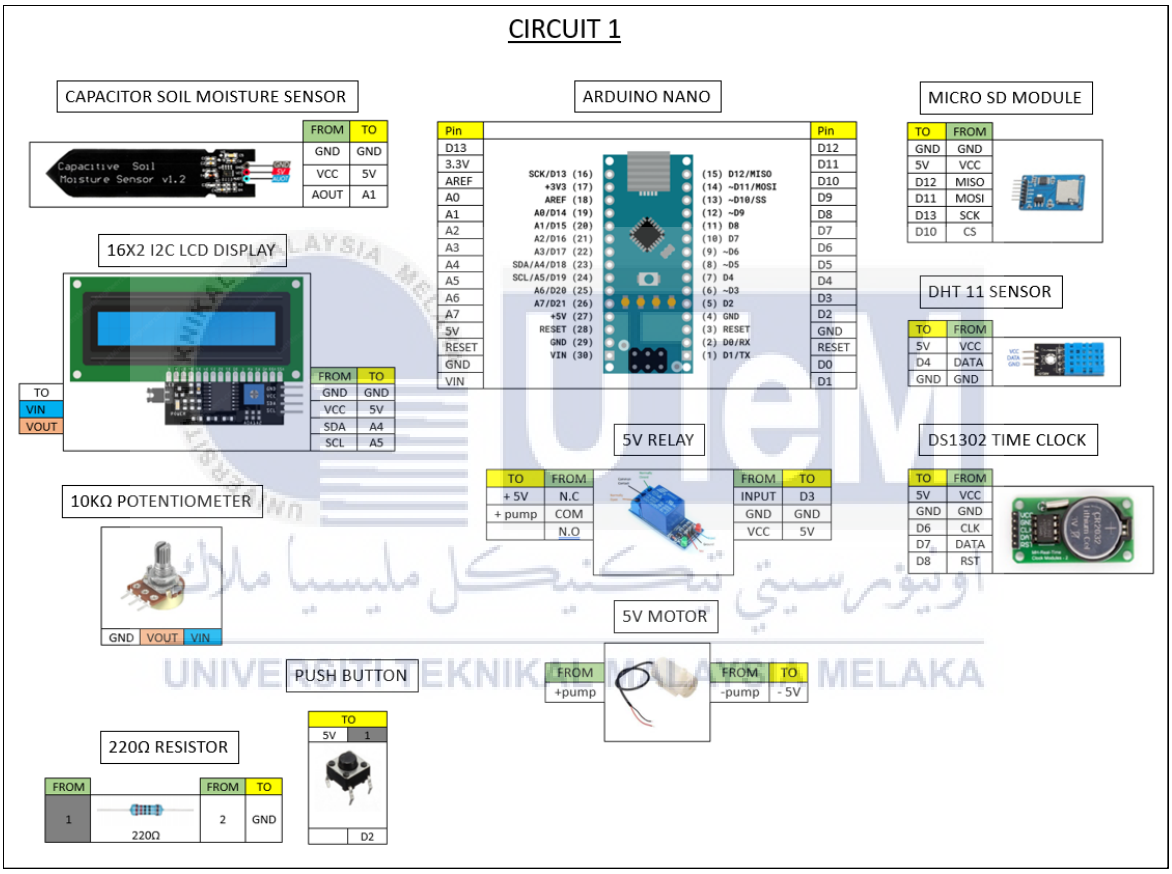


Figure 3.12: Design Circuit that interface with Arduino

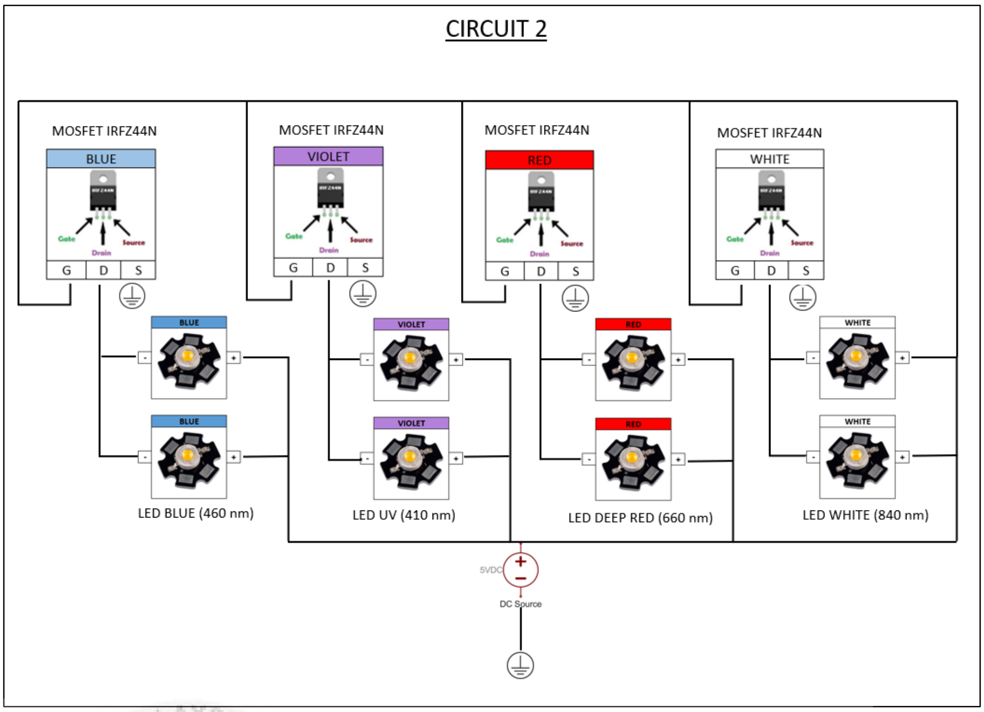


Figure 3.13: Design Circuit for LED System

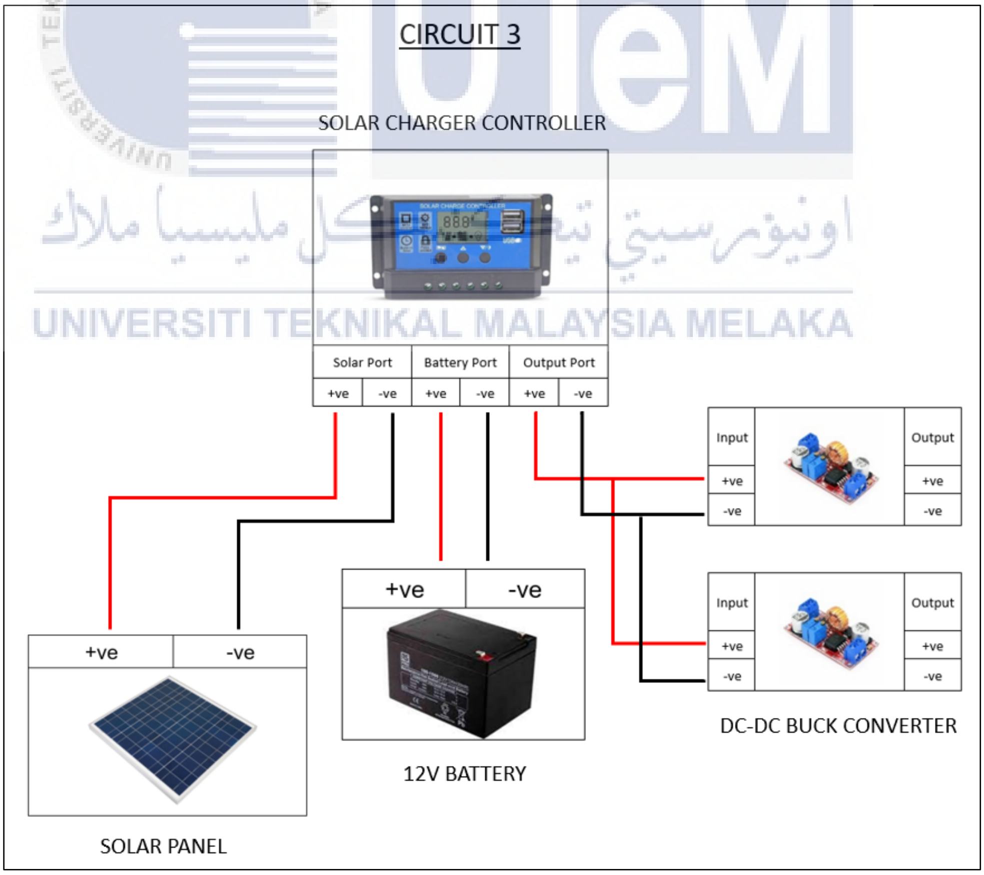


Figure 3.14: Design Circuit for Solar System

3.10 Arduino code to program the full system

This section was the Arduino code that already tested and implement on hardware.

test | Arduino 1.8.13

File Edit Sketch Tools Help

test

```
#include <Wire.h>                 // include wire library
#include <virtuabotixRTC.h>       //ArduinoRTClibrary (Special for RTC1302 using it) - Set the Time Using RTC by Makuna Library
#include <SPI.h>                  // include Serial Peripheral Interface (SPI) library
#include <SD.h>                   // include Secure Digital library for microSD
#include <LiquidCrystal_I2C.h>    // include the LCD library
#include <DHT.h>                  // include DHT11 Library

#define DHTPIN 4          // data pin for DHT11
#define DHTTYPE DHT11     // DHT 11

virtuabotixRTC myRTC(6, 7, 8);    //CLK, DAT, RST (RTC1302) // Change same as current pin
DHT dht(DHTPIN, DHTTYPE);
LiquidCrystal_I2C lcd(0x27,16,2);   // initialize the LCD library with the numbers of the interface pins
File myFile;

///////////////////////////////////////Declare Variable Part///////////////////////////////////////

const unsigned int setinterval = 1000*60;   // ?second x 60sec = ?min
unsigned long interval=setinterval;         // the time we need to wait
unsigned long previousMillis=0;             // millis() returns an unsigned long.

const int chipSelect = 10;        // Variable for SD card

// make Celcius characters:
byte Celcius[8] = {
0b10000,
0b00000,
0b01110,
0b10000,
0b10000,
0b10001,
0b01110,
0b00000,
};

// make "=" Equal characters:
byte Equal[8] = {
0b00000,
0b00000,
0b01110,
0b00000,
0b00000,
0b01110,
0b00000,
0b00000,
};

// make moisture characters:
byte Wet[8] = {
0b00000,
0b00100,
0b01110,
0b11111,
0b11111,
0b11111,
0b01110,
0b00000
};

int button = 2;                   // Variable for Time button on pin2

int relay = 3;                    // Variable for Relay on pin3 for water pump

// Variable Temp&HUmi
int h;                            // Variable for humidity
int t;                            // Variable for Temperature
```

```
// Variable Soil Moisture
const int analogInPin1 = A1;      // Analog input pin that the soil moisture sensor is attached to
const int DryValue = 447;         // analog soil sensor value (minimum dry)
const int WetValue = 340;         // analog soil sensor value (maximum wet)
int soilMoistureValue;            // variable for value read analog soil moisture sensor
int soilmoisturepercent;          // variable for analog soil moisture sensor convert to percentage

////////////////////////////////////////////////////////////////////////////////////////////////////

void character()
{
  // set character
  lcd.createChar(2, Equal);       // create a new character
  lcd.createChar(3, Celcius);     // create a new character
  lcd.createChar(4, Wet);         // create a new character

  //for Soil Moisture Sensor character
  lcd.setCursor(0,0);             // set location character (column,row)
  lcd.write(byte(4));             // byte(4) represents Wet character and print that character
  lcd.setCursor(1,0);             // set location character (column,row)
  lcd.print("%");                 // percentage for moisture
  lcd.setCursor(2,0);             // set location character (column,row)
  lcd.write(byte(2));             // byte(2) represents Equal character and print that character

  //for Water pump
  lcd.setCursor(0,1);             // set location character (column,row)
  lcd.print("Pump:");            // print character "Pump"

  //for DHT11 character
  lcd.setCursor(9,0);             // set location character (column,row)
  lcd.print("T");                 // print character "T" to represent Temperature
  lcd.setCursor(10,0);            // set location character (column,row)
  lcd.write(byte(3));             // Celcius symbol unit
  lcd.setCursor(11,0);            // set location character (column,row)
  lcd.write(byte(2));             // byte(2) represents Equal character and print that character
  lcd.setCursor(9,1);             // set location character (column,row)
  lcd.print("H");                 // print character "H" to represent Humidity
  lcd.setCursor(10,1);            // set location character (column,row)
  lcd.print("%");                 // percentage for humidity
  lcd.setCursor(11,1);            // set location character (column,row)
  lcd.write(byte(2));             // byte(2) represents Equal character and print that character
}

void readSoilSensor()
{
  soilMoistureValue = analogRead(analogInPin1);                                    // read the analog in value
  soilmoisturepercent = map(soilMoistureValue, DryValue, WetValue, 0, 100);     // mapping step to sort min and max range of analog sensor
  if(soilmoisturepercent>100)
  {
    lcd.setCursor(3,0);
    lcd.print("100");
    myFile.print("\tMoisture Percent: ");    //record "Moisture Percent" is for soil percentage
    myFile.print("100");
  }

  else
  {
  lcd.setCursor(3,0);
  lcd.print("   ");
  lcd.setCursor(3,0);
  lcd.print(soilmoisturepercent);
  myFile.print("\tMoisture Percent: ");    //record "Moisture Percent" is for soil percentage
  myFile.print(soilmoisturepercent);
  }

}

void readTemp_Humi()
{
  h = dht.readHumidity();           // read the analog humidity
  t = dht.readTemperature();        // read the analog temperature
  if (isnan(h) || isnan(t))
  {
    Serial.println("Failed to read from DHT sensor!");
    return;
  }

  // print the DHT11 data on LCD Display
  lcd.setCursor(12,0);                        // set location character (column,row)
  lcd.print(t);                               // temp value on LCD
  lcd.setCursor(12,1);                        // set location character (column,row)
  lcd.print(h);                               // humi value on LCD
}
```

```
void serialTime()
{
  Serial.print("Date/Time: ");
  Serial.print(myRTC.dayofmonth);
  Serial.print("/");
  Serial.print(myRTC.month);
  Serial.print("/");
  Serial.print(myRTC.year);
  Serial.print(" ");
  Serial.print(myRTC.hours);
  Serial.print(":");
  Serial.print(myRTC.minutes);
  Serial.print(":");
  Serial.print(myRTC.seconds);
}

void lcdTime()
{
    lcd.clear();
    lcd.setCursor(0,0);
    lcd.print("Time:");
    lcd.setCursor(6,0);
    lcd.print(String(myRTC.hours)+String(":")+String(myRTC.minutes)+String(":")+String(myRTC.seconds));
    lcd.setCursor(0,1);
    lcd.print("Date:");
    lcd.setCursor(6,1);
    lcd.print(String(myRTC.dayofmonth)+String("/")+String(myRTC.month)+String("/")+String(myRTC.year));
    delay(1000);
    lcd.clear();
}

void SDCard()
{
  myFile = SD.open("Datalog.txt", FILE_WRITE);

  if (myFile) // if the file opened okay, write to it
  {
    myFile.print("Date/Time: ");
    myFile.print(myRTC.dayofmonth);
    myFile.print("/");
    myFile.print(myRTC.month);
    myFile.print("/");
    myFile.print(myRTC.year);
    myFile.print(" ");
    myFile.print(myRTC.hours);
    myFile.print(":");
    myFile.print(myRTC.minutes);
    myFile.print("\tTemperature: ");            //record "Temperature" is for air celcius
    myFile.print(t);
    myFile.print("\t\tHumidity: ");             //record "Humidity" is for air humi percentage
    myFile.print(h);
    readSoilSensor();
  }
  else
  {
    Serial.println("error opening Datalog.txt");   // if the file didn't open, print an error:
  }
}
```

```
void Serialprint()     // print the results to the Serial Monitor
{
  serialTime();
  Serial.print("\tTemperature: ");              //"Temperature" is for air celcius
  Serial.print(t);
  Serial.print("\t\tHumidity: ");               //"Humidity" is for air humi percentage
  Serial.print(h);
  Serial.print("\tAnalog Soil: ");            //"Analog Soil" is input of soil moisture sensor
  Serial.print(soilMoistureValue);
  Serial.print("\tMoisture Percent: ");       //"Moisture Percent" is percentage of wet/dry soil
  Serial.print(soilmoisturepercent);
}

/////////////////////////////////////////////////////////////////////////////////////////////

void setup()
{
  Wire.begin();
  Serial.begin(57600); Serial.flush(); while(Serial.available()>0)Serial.read();
  SD.begin(10);                   // initialize for CS on pin 10
  dht.begin();                    // initialize for DHT11

  lcd.init();                     // initialize the lcd
  lcd.backlight();                // turn on backlight of LCD

  pinMode(button,INPUT);          // set pin2 of button as external input
  pinMode(relay,OUTPUT);          //set digital pin 3 as output of relay
}

void loop()
{
  myRTC.updateTime();
  //delay(1000);
  if(digitalRead(button)==HIGH)
  {
    lcdTime();
  }

  else
  {
    unsigned long currentMillis = millis();        // grab current time
    character();
    readSoilSensor();
    readTemp_Humi();
    Serialprint();

    if (soilmoisturepercent<=20)
    {
      digitalWrite(3,LOW);     //give "0" to open circuit (ON PUMP)
      lcd.setCursor(5,1);      // set location character (column,row)
      lcd.print("    ");
      lcd.setCursor(5,1);      // set location character (column,row)
      lcd.print("ON");

```

```
      while(soilmoisturepercent<=100)  // keep water pump ON until target set
      {
          unsigned long currentMillis = millis();       // grab current time
          myRTC.updateTime();
          //delay(1000);
          if(digitalRead(button)==HIGH)
          {
            lcdTime();
          }
         character();
         readSoilSensor();
         readTemp_Humi();
         lcd.setCursor(5,1);      // set location character (column,row)
         lcd.print("    ");
         lcd.setCursor(5,1);      // set location character (column,row)
         lcd.print("ON");
         Serialprint();
         Serial.println("\tPump: ON");     //"Pump ON" is for turn ON pump

         if ((unsigned long)(currentMillis - previousMillis) >= setinterval)
         {
          SDCard();
          myFile.println("\tPump: ON");     //record "Pump ON" is for turn ON pump
          myFile.close();                   // close the file:
          previousMillis = millis();
         }
       }
    }

    else
    {
        if ((unsigned long)(currentMillis - previousMillis) >= setinterval)
        {
          SDCard();
          myFile.println("\tPump: OFF");
          myFile.close();                   // close the file:
          previousMillis = millis();
        }

        Serial.println("\tPump: OFF");
        lcd.setCursor(5,1);              // set location character (column,row)
        lcd.print("    ");
        lcd.setCursor(5,1);              // set location character (column,row)
        lcd.print("OFF");
        digitalWrite(3,HIGH);            //give "1" to open circuit (OFF PUMP)
     }
  }
}
```


Figure 3.15: Arduino code to program the smart garden system

3.11 Chapter Summary

The stages involved in developing Arduino code, LED control systems, autonomous irrigation, monitoring temperature-based, data logging and solar energy systems are covered in this methodology title. Several aspects must be explored initially in order to build all of the systems mentioned above, with the goal of better understanding how these systems function. Knowledge of component specifications, understanding of how components arrange electricity, programming between components and programmed, and expectations of the system's operational capabilities are only a few of the considerations. The ultimate goal of this project is to design a system that will aid crop development in terms of light support, enough water retention or wet soil, and renewable energy for long-term agricultural sustainability.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter is a continuation of Chapter 3's approach, which covers the intended outcome for each needed step chosen. Numerous elements will be considered, including the real hardware implementation, performance of plant health, and the anticipated electrical power consumption for this smart garden system.

4.1 Real Hardware Implementation and Performances

After the circuit has been designed and tested to function properly, the tree needs to be concerned about its space diameter and section. This is because it relates to light, which needs to supply how much LED brightness is required to fulfil every plant space section. Furthermore, the place to put the system also needs to be considered. So, the figure of the full housing and circuit system, including piping for the plant, is as below.

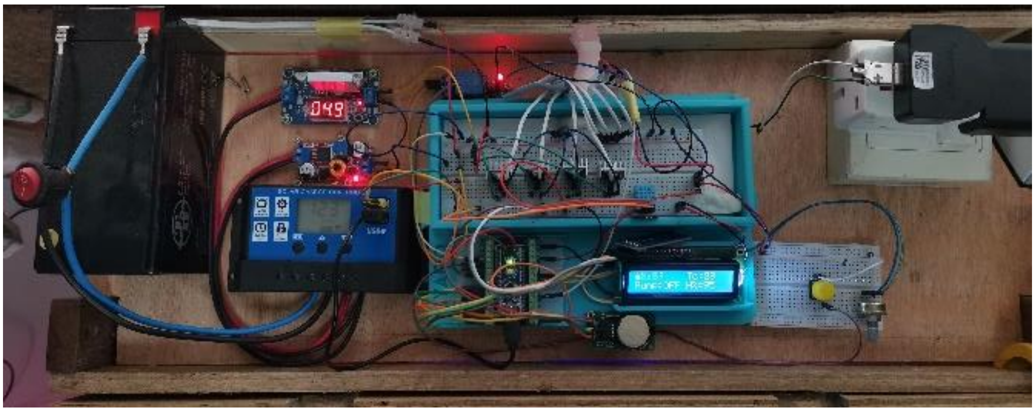


Figure 4.1: Implementation circuit of Smart Garden System

Figure 4.2: Housing for the plant includes a circuit system and piping

4.1.1 Performances of Full Smart Garden System

The system is already running according to the target time line that started on November 2nd and ran until December 27th. Along this timeline, there is data that needs to be achieved and analyzed for this system's performance. The data that has been collected includes the moisture of soil from the soil moisture sensor, temperature and humidity from the DHT11, and power consumption from solar energy. In a week, this system will run for around 9 hours. This is because we want to follow the usual time like an outdoor crop that absorbs sunlight for around 9 hours. So, below is the graph form.

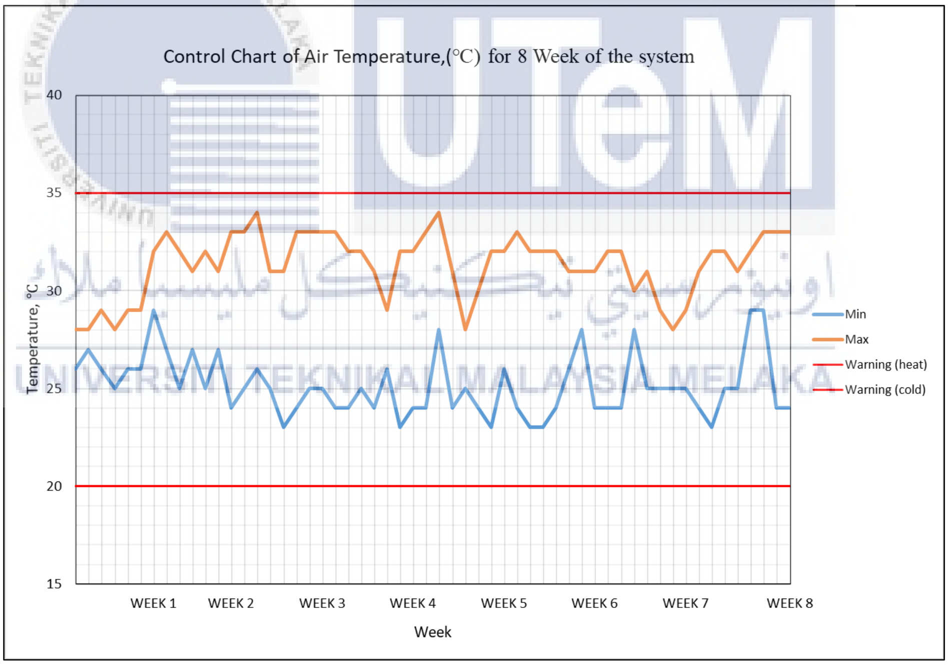


Figure 4.3: Control chart of Air Temperature, °C from DHT11 Sensor

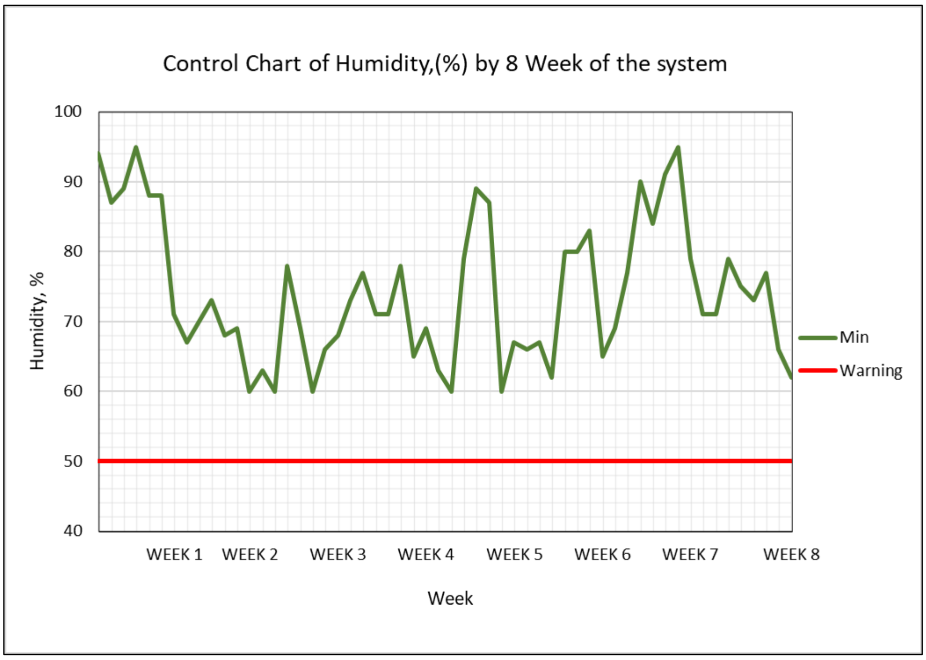


Figure 4.4: Control chart of Humidity, % from DHT11 Sensor

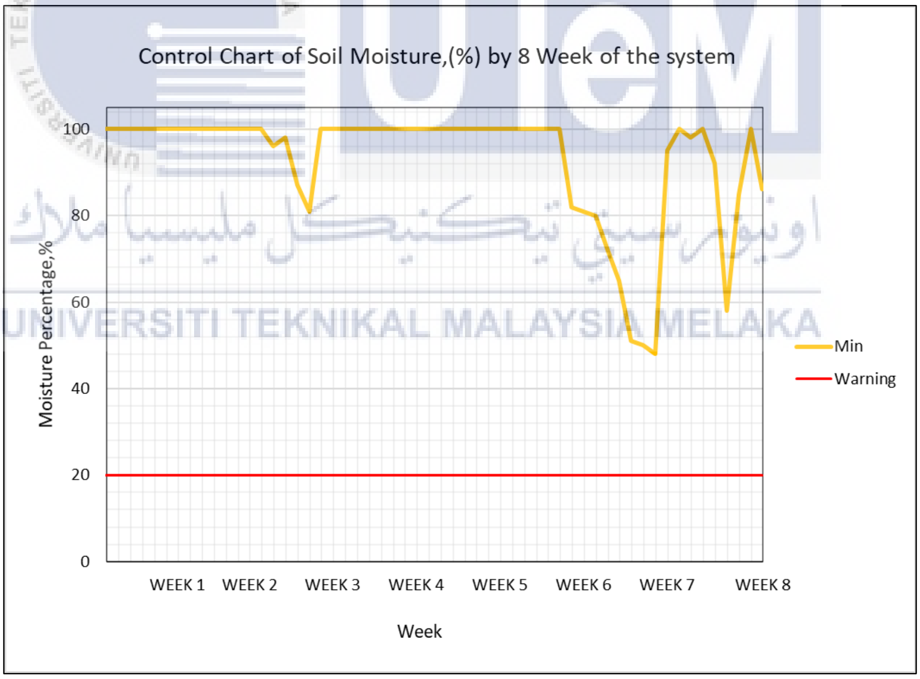


Figure 4.5: Control chart of Soil Moisture, % from Soil Moisture Sensor

The observation from control chart 4.2 shows that there are maximum and minimum temperatures that sort by a week. So, the maximum temperature every week seems under control. The target we want is less than 35°C, which is like a warm condition. Meanwhile, the minimum temperature every week is shown to be no lower than 20 °C, which is not too cold. Next is humidity, from control chart 4.3. As the data flow shows, humidity is also under control and does not reach under 50%. If this happens, it shows that the ventilation around the plant area is not in good condition or controlled. Lastly but not least, the observation from control chart 4.4 shows that the wet soil is under control and it has not reached the dry warning limit, which is below the 20% set limit. For information, there is a sense of sand and soil, which will probably have different sensitivity readings according to the data flow above. From week 1 until week 5, the sensor has been sensing the moisture of sand, and as we enter weeks 6 and 7, the sensor senses the moisture of soil.

4.1.2 Power Consumption on Smart Garden System

The construction of a system that involves the use of electrical energy from a battery should be known by the calculation of how much strength and durability the battery can withstand to operate or turn on the system. So, the table below is the estimated calculation and tested for the use of power to run this study system.

	Voltage Supply, V	Current, A	Power Dissipation, Watt
Arduino	5V	20 m	0.1
All LED	5V	1.37	6.85
Relay	5V	2.34m	11.7m
Soil sensor	5V	8.2m	41m
DHT11 sensor	5V	1.2m	6m
SD card module	5V	1.6m	8m
Motor pump	5V	20m	0.1
RTC DS1302	5V	0.1m	0.5m
LCD 16x2	5V	6.7m	33.5m
		Total Power	7.2 W

Table 4.1: Estimation on Power Consumption for all part system

Formula:

$Power(W) = Current(I)\ x\ Voltage(V)$

$Electrical\ Energy = Power\ (W)\ x\ Time(s)$

4.2 Performances of Plant Health

This part is very important because it relates to the main objective of this project, which is to use LED light to promote the growth of a plant. So, before that, the plant that has been chosen for this project is the fruit tree category that is called "Beruas." This "Beruas," also known as "Seashore Mangosteen" or "Garcinia Hombroniana," is a species of mangosteen found in Malaysia, Cambodia, Thailand, and Vietnam. The kind of data in this part contains all about a plant, such as tree height, length of leaves, width of leaves, the number of leaves that grow and also the texture of leaves. This collection data started on November 2nd and ran until December 27th. The data is shown as below.

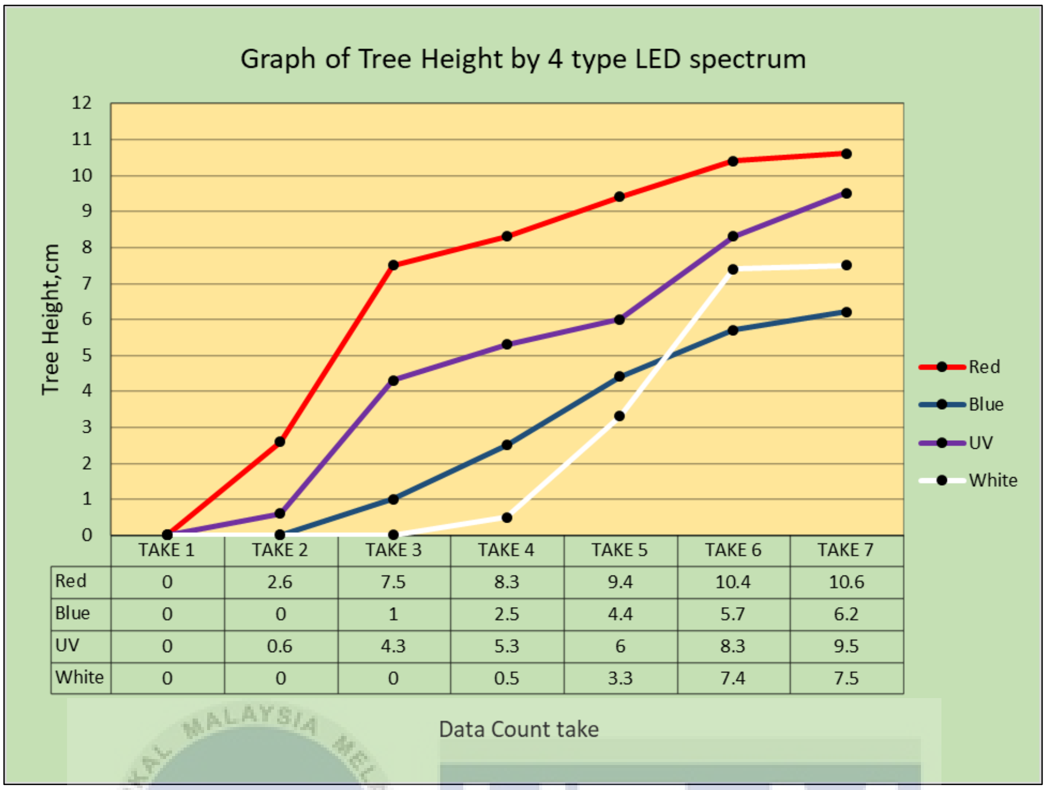


Figure 4.6: Line-graph of Tree Height among 4 types of LED color spectrum

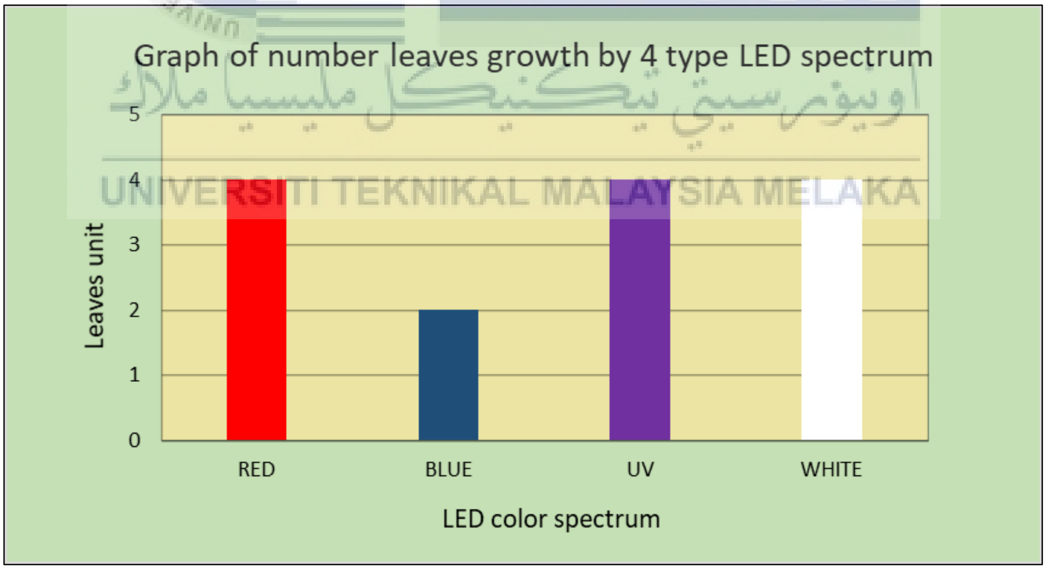


Figure 4.7: Line-graph of number of leaves among 4 types of LED color spectrum

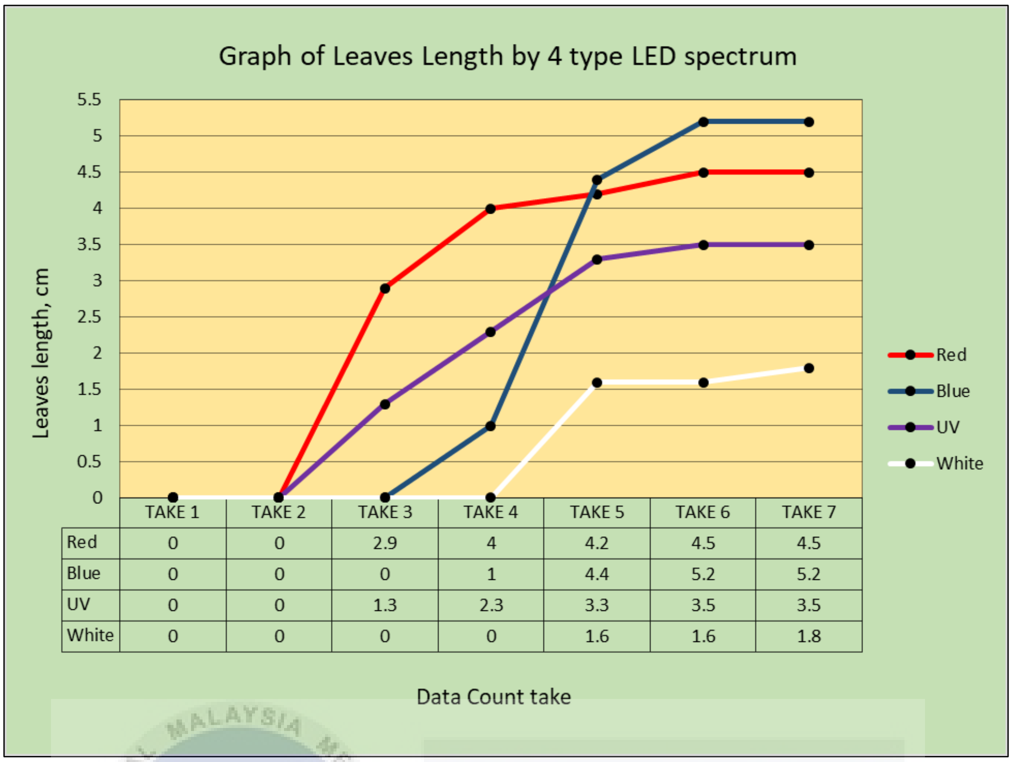


Figure 4.8: Line-graph of length of leaves among 4 types of LED color spectrum

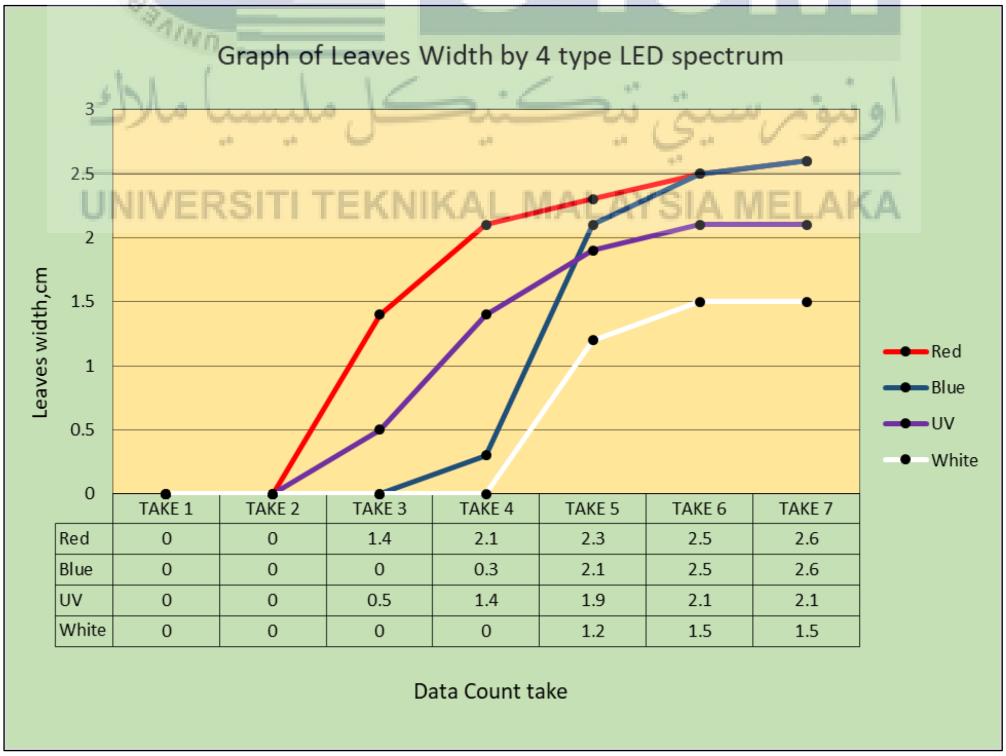


Figure 4.9: Line-graph of width of leaves among 4 types of LED color spectrum

	
Red Spectrum	**Blue Spectrum**
	
UV Spectrum	**White Spectrum**

Figure 4.10: Texture surface of leaves among 4 types of LED color spectrum

Observing from the data above, we can simply say that the use of all 4 types of LED color spectrum towards plants has had a positive effect. They have different performance standards for each plant. The first component, the tree's height, has the highest result in the RED spectrum, followed by UV, WHITE, and finally the BLUE spectrum. When compared to others, the less leaves have sided to the BLUE spectrum. Meanwhile, the length of leaves has shown the highest result in the BLUE spectrum, and the width of leaves has taken sides even in the BLUE and RED spectrum. In terms of the texture of leaves, the RED spectrum has given a shrink impact on the leaf surface compared to the other three, where there is no shrink impact. To summarize, each LED color emits its own light substances, which have an impact on plant properties. So as a final discussion and decision among the 4 types of LED spectrum regarding the collected data, which one had a good impact on the health of the plant is the UV spectrum. This is because the UV spectrum has a good average parameter among other LED spectrums. UV light, as we know, is a mixture of BLUE and RED light, indicating that the photosynthetic process accepts the BLUE and RED spectrum from sunlight, according to science hypothesis. As a result, using UV LED light to replicate sunlight can help in photosynthesis.

4.3 Chapter Summary

This chapter gives key insight on how to grow the plant using different types of LED spectrum. This result has already shown that LED light can imitate the sunlight spectrum. The plant was also controlled and monitored very well with the benefit of an automation system by using the simple task of Arduino. The performance of this system proved that it can grow the plant by using affordable technology components and save energy costs.

CHAPTER 5

CONCLUSION AND RECOMENDATION

5.1 Conclusion

On the whole, the investigations and simulation tests conducted on the system employed for this "Development of a Smart Garden by using Arduino" have produced the outcomes that were anticipated. Regarding real hardware implementation, the Arduino-based system serving as an interface between the main three systems has shown the required data and how it works. This programmed system has been created and tested very well according to the expected flow process.

Next, the technique of switching current has been used to simplify the system for controlling the brightness of LED lights. This switching using MOSFET solves problems such as when it comes to power dissipation, which will be restricted to the LED output in order to accommodate the plant's need for a certain amount of light. As a result, the use of four different types of LED light spectrum has been shown to aid in the photosynthesis process of plant growth. With proper light consumption and the right LED spectrum, we can make a decision on how we want to grow plants based on their characteristics.

In addition, the Arduino has shown good performance in monitoring the ventilation system via the use of a DHT11 sensor. This sensor collects and transmits information about the air conditions in the crop area to the Arduino and then displays it on the LCD as a monitor. This method is only for the purpose of re-cooling the crop area after it has been exposed to extreme heat. If the temperature rises above 35 degrees Celsius or the humidity falls below 10%, we can take further action, such as moving to a suitable air condition.

The irrigation system is the next item on the list. Through the use of a soil moisture sensor component, the Arduino will be able to regulate and monitor the soil moisture conditions. These sensors continually operate to measure soil resistance, regardless of whether the soil is dry or damp. So far, based on the recorded data, this irrigation system has contributed very well to water saving and making plants long-lastingly hold the water in the soil.

Besides that, the SD card module for data logging is very helpful to users that have no internet capability in order to analyze their plant or system performance when they are not around.

Overall, this all-part system is worn because it is simple to monitor and does not require the usage of Internet of Things technology. As a result, this system can be used by those who frequently engage in indoor planting activities and have limited internet access. The status of the crop can be monitored in real time and is also capable of strategically controlling the crop without the need for regular monitoring. These installation charges are easily accessible and at a reasonable cost to you.

5.2 Future Works

For future improvements, accuracy of the smart garden estimation results could be enhanced as follows:

I. Testing and data collection on energy consumption for this system so that the measurement of solar panels to charge the battery reaches an optimal and effective level.

II. Adding and testing on irrigation system with automatic systematic fertilizer process.

III. Design and testing circuit that can accommodate the load of high-power LED so that can place many plants into wide area.

IV. Create inverter system to power supply for backup when battery turn low due to solar cannot charge battery during rainy season.

V. Further manipulate Arduino programs so that all systems are systematically controlled so that technical problems can be avoided.

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