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SOLAR POWERED AUTOMATED FERTIGATION SYSTEM (I-SIRAM)

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DECLARATION

I declare that this project report entitled "Solar Powered Automated Fertigation System (I-SIRAM)" 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.



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 with Honours.

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ABSTRACT

The use of digital agriculture, sometimes known as smart farming or e-agriculture is the new frontier to empower the agriculture sector by infusing IR4.0 technologies, such as the Internet of Things (IoT) in agriculture. The emergence of IoT technology has contributed to the progress of intelligent farming from manual and conventional farming through trial and error to precision agriculture through digital technology. Therefore, I-SIRAM has been developed as a digital solution for precision and smart agriculture. I-SIRAM is an IoT-based automated fertigation system that uses solar-powered to control the injection of fertilizer intake with the intention of tackling the overdose of fertilizer and watering intake. I-SIRAM is developed to automatically agitate a proper proportion of fertilizers, and watering and to implement solar-powered automatic fertilizer that can cut the electricity accessibility issues. Arduino UNO is selected as the microcontroller to program the system while pumps, motors, and sensors are used to initiate the agitation of fertilizer A, fertilizer B, and water into the mixer tank. The system has been built accordingly and the performance of the system has been tested. What makes the project unique is that it is automatic, energy sufficient, 100% accurate, and fully electronic control. With the aid of solar energy and IoT implementation, the automatic fertigation system will bring lots of benefits regarding cost, productivity, labor, human health, and the ecosystem. This system has been tested in real-time and now is ready for commercialization

ABSTRAK

Penggunaan pertanian digital, kadangkala dikenali sebagai pertanian pintar atau e-pertanian merupakan sempadan baharu untuk memperkasakan sektor pertanian dengan menerapkan teknologi IR4.0, seperti Internet Perkara (IoT) dalam pertanian. Kemunculan teknologi IoT telah menyumbang kepada kemajuan pertanian pintar daripada pertanian manual dan konvensional melalui percubaan dan kesilapan kepada pertanian jitu melalui teknologi digital. Oleh itu, i-SIRAM telah dibangunkan sebagai penyelesaian digital untuk pertanian jitu dan pintar. I-SIRAM ialah sistem fertigasi automatik berasaskan IoT yang menggunakan kuasa solar untuk mengawal suntikan pengambilan baja dengan tujuan untuk menangani lebihan dos baja dan pengambilan air. i-SIRAM dibangunkan secara automatik dengan memberi kuantiti baja yang betul, dan menyiram serta melaksanakan baja automatik berkuasa solar yang boleh mengurangkan isu kebolehcapaian elektrik. Arduino UNO dipilih sebagai mikropengawal untuk memprogramkan sistem manakala pam, motor dan penderia digunakan untuk memulakan pengadukan baja A, baja B dan air ke dalam tangki pengadun. Sistem telah dibina dengan sewajarnya dan prestasi sistem telah diuji. Apa yang menjadikan projek itu unik ialah ia automatik, cekap tenaga, 100% tepat dan kawalan elektronik sepenuhnya. Dengan bantuan tenaga suria dan pelaksanaan IoT, sistem fertigasi automatik akan membawa banyak faedah berkaitan kos, produktiviti, buruh, kesihatan manusia dan ekosistem. Sistem ini telah diuji dalam masa nyata dan kini sedia untuk dikomersialkan.

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LIST OF SYMBOLS

SYMBOLS

SCALES

°C

 $mScm^{-1}$

Temperature

Electrical Conductivity (EC)



LIST OF ABBREVIATIONS

| ICT | - | Information and Communication Technology |
|-----|---|--|
| IoT | - | Internet of Things |
| UAV | - | Unmanned Aerial Vehicle |
| ML | - | Machine Learning |
| WSN | - | Wireless Sensor Network |
| EC | - | Electrical Conductivity |
| TDS | - | Total Dissolved Solids |
| AI | - | Artificial Intelligence |
| | | |



CHAPTER 1

INTRODUCTION

1.1 Background

In recent years, automation and IoT have been merged with traditional farming. Remote sensing technologies, for example, Big Data, Internet of Things (IoT), and Unmanned Aerial Vehicles (UAVs), are particularly promising. They have the potential to provide a new way in agricultural techniques. In a wide range of agricultural parameters can be monitored to help with smart farming, increase crop yields, lower costs, and optimise process inputs such as environmental protection circumstances, growth status, soil quality, irrigation water, insect, and disease problems, and so on. But these technologies are a barrier for a small farmer to improve their plant management. This is because the capital to use the technologies is high. In this era of modernity, everyone should experience the greatness of technology that can simplify daily affairs. Therefore, in this project, we proposed a smart system agriculture that can be used by everyone that love to cultivate.

1.2 Problem Statement

The increased demand for food, in terms of quality and quantity, has accelerated the need for agricultural modernization and intensive production techniques. To determine the exact amount of water and Electrical Conductivity (EC) necessary for the plant is a huge challenge. A farmer will find it difficult to water and give enough nutrient for their plant. It is either the water is too much or too less. An EC meter, pH value, and temperature sensor is placed and operated utilising several IoT strategies to prevent those problems. EC meter

monitoring also has been one of the most difficult tasks in agriculture for both cultivator and farmers. Soil testing raises a few environmental issues that have an impact on agricultural output. Soil management requires determining several soil properties including pH and EC value. These metrics can be easily computed with the help of IoT sensors.

Next, existing technology in agriculture is too expensive for a small farmer. Based on market price, a starter UAV can be around \$850 (Lawson, 2017). In Malaysia, the cost for manage a Greenhouse structure can be around RM 20,000 per unit (Anem, 2010). The price may increase from year to year. This amount of price is way too much for a small farmer. A low-cost technology must be proposed to help the small farmer. Next, EC meter, pH value, and temperature of the plant is difficult to monitor without using the IoT. Nowadays, most of the technology are using IoT such as connected vehicle, traffic management, smart buildings and smart homes, smart cities, supply chain management, and more (Pratt, 2022). Other than monitoring the plant, IoT also can enhanced the productivity of the crop and provide better quality control.

1.3 Project Objective UNIVERSITI TEKNIKAL MALAYSIA MELAKA

The main aim of this project is to propose a systematic and effective methodology to develop an Internet of Things (IoT) fertilization system for smart agriculture. Specifically, the objectives are as follows:

- a) To design an affordable fertilization system using Arduino and IoT.
- b) To analyse the measurement of the fertilization system based on pH value, EC meter, and temperature.
- c) To evaluate the performance of transmission of the sensor's data to the cloud data is done in real time.

1.4 Scope of Project

To avoid any uncertainty of this project due to some limitations and constraints, the scope of the project is defined as follows:

- a) The sensor has three different types which is EC meter sensor, temperature sensor, and pH value sensor.
- b) The type of plant is limited to houseplant, annuals and biennials, alpines. This project is not involved aquatic plants, cacti and succulents, and the others.
- c) Type of software used is Blynk and Arduino. Platform used is

Windows and Android.

1.5 Thesis Outline

In Chapter 2, this thesis explains about the literature review. Based on five articles in the recent years, there is a lot of technology fertilization system for smart agriculture. This chapter will focus more on the theory about the existing technology such as UAV, wireless sensor, and more.

In Chapter 3, this thesis will focus more on the development of this project. Type of sensor, hardware, and software will be discussed.

In Chapter 4, the result of this project is presented. All the analysis and result will be discussed based on the research methodology.

In Chapter 5, the development of this project will be concluded, and the future potential work will be discussed.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

After studying the development of an IoT in fertilization system for smart agriculture from previous articles, (Ayaz, 2019) state that the potential of wireless sensor must be implement into the agriculture sector. From others article, (Dr. Bam Bahadur Sinha, Dr. R. Dhanalakshmi, 2022), farmers can connect to their farm from almost anywhere by using IoT technology. Sensors and actuators are used to control farming processes, wireless sensor network is being used to monitor the farm. In this article, wireless cameras and sensors were used to remotely monitor the farm and collect all the data. (Achilles D. Boursianis, 2020) had described the main principles of IoT technology, including intelligent sensors, IoT sensor types, networks and protocols used in agriculture. The researcher focuses more on the role of Unmanned Aerial Vehicle (UAV) technology in smart agriculture, by analyzing the applications of UAV in various condition. Next, (G. Valecce, 2019) use the concept of solarfertigation which is an IoT system that are designed specifically for smart agriculture. Lastly, (Raheela Shahzadi, 2016) use sensors to collect the real-time data and send to the server to be deployed for extracting the information from sensor data.

2.2 What is Agriculture

Agriculture is the broadest term for the various methods in which crop plants and domestic animals support the worldwide human population by supplying food and other necessities products. Agriculture is derived from the Latin words *ager* (field) and *colo* (farm) or (cultivate). When the Latin words agriculture and tillage are combined, the result is agriculture. However, the word has arrived to encompass a broad range of activities that are essential to agriculture and have their own distinct identities such as cultivation, domestication, horticulture, arboriculture, and other descriptive phrases (Harris & Fuller, 2014). In Malaysia, agriculture sector has been introduced around 1780s with the arrival of British in Penang. British interest to develop a plantation agriculture which is pepper in Penang (Joseph, 2008). Pepper planting in Penang continue from 1790-1825 and it was the first exported agriculture products in Malaysia. In India, there are various type of farming systems including subsistence farming, shifting agriculture, plantation agriculture, intensive farming, dry agriculture, mixed and multiple agriculture, crop rotation, and terrace cultivation (Anon., 2016). All these types of farming have different ways and roles, but the output is same which is to produce agricultural products. Malaysia should take the example of the action taken by India to improve our product quality and quantity in agriculture.

2.3 Wireless Sensor in smart agriculture

The purpose of wireless sensor in smart agriculture is to obtain the variety of environmental parameters such as temperature, pH value, soil moisture, and humidity. By UNVERSITITEEXNEAL MALAYSIA MELAKA using this sensor in agriculture, it can enhance the quality and quantity of the crops by farmer. In agriculture, the amount of moisture in the soil has an important effect in plant growth. Directly checking the wetness of the farm field is possible. An agricultural field's moisture and temperature can be measured with a thermometer and a hygrometer. Wireless sensor network (WSN) can be used to obtain data from a wireless sensor network so that the server can provide typical server services to all clients at all times and from any location. To assist smart farming, a WSN Server is required to service all agricultural data needs so that the data may be analysed and optimised for smart farming demands. The wireless sensor network server acts as a server, receiving data from many sensors over WSN. The data is subsequently saved in real time to a database, then visualised as a website that can be acquired via the Internet. A (WSN) is a network system that connects sensors and transmission devices to a WSN server to receive information or data. WSN is typically used to monitor the environment in agricultural or plantation settings.

2.4 Role of UAV technology in smart agriculture

In recent years, unmanned aerial vehicles have emerged as a low-cost alternative in sensing technologies and data analysis techniques. Remote sensing is a technique that uses electromagnetic energy to identify the qualities of a target object from a distance. It has the advantages of being comprehensive, non-invasive, timely, and flexible. UAV can be used in agriculture to collect data in the field. The advantages of a UAV are that it can capture images of a farmer's crop with a variety of camera filters, providing multiple spectral imaging, allowing image processing and analysis, and providing better information on their crop's health while also identifying areas of the crop that require special attention. Fixed wing and multirotor UAVs are the two types of UAVs available. Multirotor UAV can load multiple types of sensors and due to that it may limit the battery lifetime and flight time. Fixed wing has a better flight time but has a lower speed compared to multirotor.

2.5 Solar fertigation

Solar fertigation is a precision irrigation system that uses photovoltaic solar power energy and an Internet of Things technology. Temperature, radiation, humidity, soil moisture, and other physical characteristics are all monitored by the system. Solar fertigation makes use of renewable energy sources photovoltaic panels for smart irrigation and decisionmaking assistance for farmers using Internet of Things technologies. Using a hybrid predictive model, a novel irrigation control technique has been developed. Real-time sensors and a model based on weather and crop data were described. Solar fertigation relies on a low-cost WSN that monitors and transmits locally or to an on-cloud software platform. WSNs are practically energy independent. The prototype detected soil and environmental characteristics in the field to check crop growth and assist farmers in decision-making phases related to the growth processes of grown crops.

2.6 IoT in Agriculture

In agriculture, the development of IoT has high potential to produce a better product. With this kind of technology, the farmer or administrator can control or manage the plant needed. With the used of web-based and mobile application, farmer can manage agricultural plots and control the watering systems. Furthermore, IoTs were used in the agro-industrial production chain. They suggested a unique architecture based on the IoT, combining wireless and distributed sensor devices with environmental simulation to follow the evolution of grapes for wineries (Jirapond Muangprathub, 2019). An IoT-based farm information system with a distributed design is presented. The IoTs servers were used to track and trace the entire agricultural production process. Several studies have been conducted to increase the functionality of IoTs. For this purpose, several sensors have been used to measure temperature, solar radiation, humidity, and rain with the control of an electronic device which is Arduino and Android-based smartphone.

2.7 Smartphone's User in Malaysia

In IoT platform, smartphones are important because it is related to each other. Without smartphone, whether it is Android or Internetwork Operating System (IOS), IoT cannot be implemented. In Malaysia, smartphone's user is seeming to be increase throughout the year up to 2025. The increasing number in smartphone user is due to increasing growth population. Based on research, the number of smartphone's user in Malaysia is about 29 million in 2021 and is expected to increase as much as 1.74 million in 2025 [1]. This is a positive result in term of IR 4.0 to implement the IoT platform. Graph below shows the number of smartphone user in Malaysia from 2010 until 2025. The data is taken from Statista that run the statistical analysis.



Figure 2.1 Number of Smartphone's User in Malaysia (Taken from Statista)

2.8 Productions of Vegetables in Malaysia

The productions of vegetables in Malaysia are increasing from 2015 to 2021. But it is not enough comparing to other countries especially in Asia region. For example, Vietnam produces 17 million metric tons of fresh vegetables in 2020 and Malaysia produces lower than that. The IoT in smart fertigation can affect the production of vegetables in positive term. Vegetable production on global scale increased significantly between 2000 and 2020, rising from 682 million metric tonnes in 2000 to more than 1.15 billion metric tonnes in 2020 [2]. Graph below shows the top ten producers of vegetables in 2020.



Figure 2.2 Producers of Fresh Vegetables Worldwide (Taken from Statista)

2.9 Traditional Farming versus Modern Farming

Traditional farming is describing as a primitive method of agriculture that uses labour-intensive, traditional knowledge, tools, resources, organic fertiliser, and the farmers' long-standing cultural traditions. Modern farming methods refers to a style of agricultural production that makes extensive use of technology to boost crop yields and productivity. Table below show the main differences between traditional and modern farming.

| Traditional Farming | Modern Farming | | |
|--|---|--|--|
| - 1 A M A - | | | |
| Based on labour-intensive | Based on capital intensive | | |
| Crop, slash, and agroforestry is some of | Monocropping, automated fertigation, is | | |
| the technique used | some of the technique used | | |
| | | | |
| Natural fertilizers | Chemical fertilizers | | |
| يك مليسيا ملاك | اونيةم سية تتك | | |
| Production rate is low | Production rate is high | | |
| UNIVERSITI TEKNIKAI | MALAYSIA MELAKA | | |
| High inputs required | Low inputs required | | |
| | | | |

Table 2.1 Difference between Traditional Farming and Modern Farming

From the table above, modern farming has a better benefit in terms of production. When modern farming is applied into every house, it can increase the crop yield so that it can benefits the user.

2.10 Limitation of the proposed project

This thesis is focusing to develop a fertilization system using IoT for smart agriculture. To achieve that, the measurement of the fertilization system based on pH value, EC meter value, and temperature will be analyse. By using an analogue pH meter with temperature compensation feature that designed for Arduino controller, it will detect the pH value of the water. The data from the sensor will be send to the cloud data in real time via Blynk. Most soils have pH values between 3.5 and 10. In higher rainfall areas the natural pH of soils typically ranges from 5 to 7, while in drier areas the range is 6.5 to 9. The neutral pH value for soil is 6.5 to 7.5, the value over 7.5 is alkaline, and the value less than 6.5 is acidic (Anon., 2013). If the soil is acidic, a warning will be sent to the data base and remind the user to add pulverized limestone to the soil to raise the pH value. If the soil is alkaline, a warning will be sent to the data base and remind the user to add elemental sulphur or iron sulphate to lower the pH value. The analogue pH meter comes with temperature compensation feature. But, in this project, the pH value is focusing more on the fertilizer itself. The pH value of the fertilizer is important to be monitored because its indicated whether the solution is acidic or alkaline. Too much acidic or too much alkaline is not suitable for plant's growth.

The normal temperature for most house plants is between 15°C-24°C. In Malaysia (Anon., 2016), the normal temperature is between 21°C and 32°C so, we do not have to worry if the plant's temperature is lower than the normal temperature. If the sensor detect temperature of the plant is higher than the normal temperature, it will be sent to the data base to remind the user to use shade curtains to reduce the light.

For the EC meter value, it is based on stage of the plant. Normally, a plant will have three stages which is early vegetative, middle vegetative, and generative stage. For example, chili's growth on early vegetative is around $1.2 - 1.5 \text{ mS} \text{ cm}^{-1}$, middle vegetative on around

2 mS cm^{-1} and 3 – 3.5 mS cm^{-1} on generative stage [3]. The right amount of EC value is important to plant to ensure that they get enough nutrient including micronutrient and macronutrient.



2.11 Summary of five articles

| No. | Author | Component | Method | Pros | Cons |
|-----|---|--|--|--|--|
| 1. | Dr. Bam Bahadur Sinha Dr. R. Dhanalakshmi | Software: Cooja, AVR-IoT, Raspbian OS, Proteus 8 Simulator Hardware: ESP8266, RTC Module, DHT11, GSM Module, PIC Micro-Controller, LM35. | IoT technology allow farmers to connect to their farm from anywhere and anytime. To capture films and photograph, wireless cameras and sensors were utilised. | Providing farmers with a diverse set of tools to address several challenges faced by them on the field. | Security is a big issue while using wireless networks. The speed of the wireless network is slower than the speed of wired networks. |
| 2. | Muhammad Ayaz Mohammad Ammad-Uddin Zubair Sharif Ali Mansour El-Hadi M. Aggoune | Software: Ag Premium Weather, Hardware: Loup 8000i, XH-M214, PYCNO, MP406, Yieldtrakk, SD-6P | Potential of wireless sensors and IoT in agriculture, as well as the challenges expected to be faced when integrating this technology with the traditional farming practices. | Improve the solutions of many traditional farming issues, like drought response, yield optimization, land suitability, irrigation, and pest control. | The sensor that they use can be affected by environmental changes and contamination |

Table 2.2 Comparison between five articles in the recent years

| 3. | Giovanni Valecce Sergio Strazzella Antonio Radesca Luigi Alfredo Grieco | Software: JavaScript, Express, NodeJS Hardware: Raspberry Pi 3 Model B+, Xbee s2c, Nickel-Metal Hydride (NiMH). | Solar fertigation, an IoT system specifically developed for smart agriculture, is proposed to detect the important terrain factors, which will be used to make a decision making that will control automated fertilisation and irrigation systems. | Solar fertigation is designed to integrate the decision-making process and both the fertilization and irrigation automation. This system is designed to be energy selfsufficient. | High Initial Cost |
|----|--|--|--|---|---|
| 4. | Achilles D. Boursianis Et al. | Software: OnFarm, Phytech, Semios, EZFarm, Cropx Hardware: Soil water sensor, soil moisture content sensor, pH sensor, temperature sensor, wind speed sensor | Present the uses of UAV in various scenarios, such as irrigation, fertilisation, pesticide use, and more. | Allow farmers to constantly monitoring their crops' condition by air to find problems quickly and at the same time reduce time consumed for ground-level spot checks. | Most of the drones have less flight time and covers less area Need to obtain government clearance in order to use it. |
| 5. | Raheela Shahzadi Muhammad Tausif Javed Ferzund Muhammad Asif Suryani | Software: CLIPS (C Language Integrated Production System) Hardware: Soil sensor, Temperature | The sensors collect the real-time data and send to the server. On the server side, ES have deployed for extracting the information from sensor data. | -Efficient Crop Management. Irrigation Control -Environment Warnings and Guidance | Cannot be controlled remotely. |

| | Sensor, Humidity | -Optimal usage of | |
|--|------------------|-------------------|--|
| | sensor | fertilizers, | |
| | | insecticides, and | |
| | | pesticides. | |
| | | | |
| | | | |



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2.12 Summary

In the age of technology, there are so many kinds of technology that we can use to develop a smart system in agriculture. This effort is nothing more and nothing less than for the convenience of the peasantry. Agriculture today makes extensive use of advanced technologies such as robotics, temperature and moisture sensors, UAV, and GPS technology. Businesses may be more profitable, productive, safer, and environmentally friendly thanks to modern technology, precision agriculture, and robotic systems. Based on the literature review, the technology that have been applied in the recent years give many advantages to the farmer, but this technology also has disadvantages from various sectors. For example, the cost to use this technology is very expensive. Not every farmer is able to install the technology such as wireless sensor, UAV, and robotics. In Malaysia, there are few places that have limited internet access, and this can interrupt the use of WSN. Furthermore, all the technology invention in the recent years is focusing to advanced farmer. Meanwhile, small farmer or mothers who love to cultivate can't get a feel for the technology. This is because EKNIKAL MALAYSIA MEL of the expensive cost and limited internet access. To fix the problem, we must create an affordable technology, so that everyone can use it in agriculture specially.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In general, there is a lot of smart system fertilization technology in agriculture but, not everyone can use the technology because it is not affordable for small farmer or people who love to cultivate. Nowadays, we want to make sure that everyone can use existing technology but in the cheapest way. For example, Apple produce a very good quality of smartphone, but the price is too expensive for some people so, there is an option to use Android that offer an affordable smartphone. Because of that, this thesis will focus to develop an affordable smart system fertilization using IoT in agriculture.

3.2 Proposed system



Figure 3.1 below shows the general flowchart of this system

Figure 3.1 General flowchart

Three types of sensors will be used continuously to collect data from the plant. EC meter sensor will collect EC value from the fertilizer solution. The data will be stored in the Arduino Uno and then transmit to the data-based via Wi-Fi. From the data-based, the user can monitor the EC value through their smartphone. This working progress also same with the pH value sensor and temperature sensor. Figure below shows the overall design for I-SIRAM.



Figure 3.2 Overall design of I-SIRAM

3.2.1 Experimental setup

This thesis presents an affordable smart system fertilization in agriculture. Three types of sensors which is temperature, pH value, and EC meter will be used to collect data which is EC value, pH value, and temperature. The data will be sent to the cloud data based via Blynk. The user can analyse the data through the app on their smartphone. Subsequently, Figure 3.1 shows the research design of this thesis. User also can pump fertilizer with desired value of EC which is less than $3 \text{ mS} \text{cm}^{-1}$ to the plant by using peristaltic pump.



Figure 3.4 Schematic diagram of relay module

3.2.1.1 Parameters

To run this project, we use EC value of fertilizer solution as the parameters to indicate the sufficient of nutrient for the plant. The EC value of the fertilizer is important to make sure that the plant get enough nutrient. The type of the plant is chili pepper, or its scientific name is *Capsicum Annuum* which is extensively cultivated all over the world. Besides, the solution of the fertilizer is used to collect pH value and soil temperature's data to be monitored. Type of fertilizer used is Fertilizer A and Fertilizer B that contain a lot of multi-nutrients like Calcium, Iron, Magnesium, Manganese, Zinc, Copper, and more. The role of fertilizer is important to the plant to maintain the water intake, to increase the growth of roots and improve the seed's formation [4].



Figure 3.5 Capsicum Annuum

Figure 3.6 Fertilizer A and B

3.2.1.2 Equipment

In this project, the combination of software and hardware is used to produce I-SIRAM. The list of software and hardware used is listed below:

Software

- Arduino IDE
- Blynk



• pH sensor



• 18650 Li-Ion Battery



• DS18B20 1-Wire Temperature Sensor – Waterproof





• DFR0063 I2C 16x2 Arduino LCD Display



• Arduino Uno Rev3



• ESP8266 Wi-Fi module



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3.2.1.3 Flowchart of the System



3.3 Hardware Design

An Arduino Uno, sensors such as DS18B20 temperature sensor, EC meter sensor, pH value sensor, a NodeMCU (ESP8266), are used. The software comprises of an android application that allows user to monitor their plant via Blynk. When the EC parameters measured fall below the threshold value, the user can run the peristaltic pump through their smartphone and fertilizer A and fertilizer B will be given to plant. The Arduino Uno board functions as an IoT gateway and regulates all the operations on the board. All physical parameters are sensed by sensor, which convert the analogue value to a digital value. Figure 3.3 below shows the circuit design for this project.



Figure 3.7 Circuit Design

3.4 IoT Implementation



Figure 3.8 IoT Implementation

A smart agriculture fertilization system based on the Internet of Things is used to make decisions based on real-time data. Firstly, the user will open the android application on the smartphone. User will see the data through the output of the sensor. Temperature, EC meter, and pH value are all measured. Arduino Uno Rev3 microcontroller board is attached to all these sensors because it has the capability to communicate data to the cloud. This board serves as an IoT gateway in this built system. A Wi-Fi ESP8266 module is used to transmit the data.

3.5 Blynk Interface



From the Blynk interface, user can monitor their pH and EC value. The user also can turn on their peristaltic pump through their smartphone. It is very simple and convenient to be used.

CHAPTER 4

RESULTS

4.1 Introduction

This chapter presents the results and analysis on the Solar Powered Automated Fertigation System (I-SIRAM). This project can make fertigation seems effortless through advancement technology and a few research. To make this project run smoothly and exceeds expectation, countless hours has been put in research and finding. Through the testing and examination, I-SIRAM have been documented and analysed to provide a better fertigation system that can simplify daily life of the user. In IR 4.0, all work in term of daily life can be done by using IoT platform. Nowadays, everyone has their smartphone and the use of IoT can be implemented among the smartphone's user. Besides, the user of I-SIRAM can get benefits from the plant that they cultivate for example, they can pick vegetables that they plant to be eaten. A lot of plantation agriculture can be done efficiently through this advancement of technology.

In this project, EC meter value is the priority of the parameter. This is to show the electrical conductivity in the fertilizer that is very important to indicate the quality of the fertilizer solution. Why is EC used instead of Total Dissolved Solids (TDS)? This is because all nutrition that is needed by plant is commonly charged particle ion. When TDS is used, it will measure all the substances that have been dissolved in the solution including both organic and inorganic compound. Hence, EC meter is suitable because its only measure charged particle ion that contain in plant's nutrition.

4.2 Hardware Development

For hardware development, I-SIRAM focusing on three main box consists of Box A, Box B, and Box C. Each of the box have main function of itself. The supply voltage is come from the solar powered. Solar powered is used to implement the renewable energy and save energy cost. Figure below shows the development of I-SIRAM.



Figure 4.1 Development of I-SIRAM

As figure above, three main box is connected to solar powered. I-SIRAM also provided water tank to keep the water for the plant. The water will be used to mix fertilizer A and B. The water tank can keep water approximately to 120L. Figure below shows Box A that consists of LCD screen, Arduino UNO and NodeMCU ESP 8266. This box will control the main system including the reading of parameter and running the pump.



Figure 4.2 Box A

For Box B, its contain 12V Battery that is connected to the solar panel. It is the main supply voltage to run the water pump. To connect Box A to Box B, relay module is used to control the running of peristaltic pump. Double relay module will control the peristaltic pump and single relay module will control the water pump. Figure below shows Box B.



Figure 4.3 Box B

In Box C, it contains peristaltic pump that will control the intake amount of fertilizer A and B. Peristaltic pump is a mechanical pump that generates pressure by a constriction moving along a tube. Figures below shows the peristaltic pump.



Figure 4.4 Box C

4.3 Software Development

To develop the system, Arduino IDE is used to write the coding. The program is divided into two which is to program Arduino UNO and another one is NodeMCU. Arduino UNO is programmed to store the parameter's library including temperature sensor, pH sensor, and EC meter sensor. From this program, it will enable the value of the parameter to be shown in the LCD screen. Figure 4.5 below will show the coding for Arduino UNO.



```
bTemp = bTab[(iFilterLen - 1) / 2];
                                        }
                                        else {
                                              bTemp = (bTab[iFilterLen / 2] + bTab[iFilterLen / 2 - 1]) / 2;
                                        }
                                        return bTemp;
                                 }
                                 float ph (float voltage) {
                                       return 7 + ((2.5 - voltage) / 0.18);
                                  }
                                 LiquidCrystal_I2C lcd(0x27, 16, 2);
                                 SoftwareSerial nodeMCU(2, 3);
                                 boolean statel = true;
                                 boolean state2 = true;
                                 void setup() {
                                      pinMode(pHSense, INPUT);
                                        Serial.begin(115200);
                                        nodeMCU.begin(9600);
                                       ec.begin();
                                        lcd.begin();
                                       lcd.backlight();
                                 1
                                 void loop() {
                   MAL
                                     StaticJsonBuffer<200> jsonBuffer;
                                        JsonObject& data = jsonBuffer.createObject();
                                        float phValue = PH_sensor();
                                        delay(15);
                                       Serial.print("PH=");
                                        Serial.println(phValue);
                                        lcd.setCursor(8, 0);
                                        lcd.print("PH:");
                                       lcd.setCursor(11, 0);
                        lcd.print(phValue, 2);
                                        char cmd[10];
                                        static unsigned long timepoint = millis();
                                                                                                                                                                                                                5:
                                                                                         6
                                            _{ijk}
                                                                 \sim 10^{-10}
if (mills() - timpoint > 10000) //time interval: is
{
    timpoint = hills();
    timpoint = hill
                               if (millis() - timepoint > 1000U) //time interval: 1s
                            if (readSerial(cmd)) {
    strupp(cmd);
    if (strut(cmd, "EC")) {
        ec.calibration(voltage, temperature, cmd); //EC calibration process by Serall CMD
    }
}
                             data["PH"] = phValue;
data["EC"] = ecValue;
data.printTo(nodeMCU);
jsonBuffer.clear();
                         int i = 0;
bool readSerial(char result[)) {
    while (Serial.available() > 0)
    char inChar = Serial.read();
    if (inChar = `\n') {
        result[i] = `\0';
        Serial.flush();
        i = 0;
        return true;
```





NodeMCU is programmed to connect the hardware to Wi-Fi. The value of EC will be received from the sensor. From the value, it will state a condition if the value is less than 4 mS/cm or more. If the value is less, water pump will on but if its value is more then water pump will off. Before that, this condition will be declared after the peristaltic pump A and B is on. NodeMCU also used to control the pump by using Blynk that is connected to Wi-Fi through NodeMCU. Figure below shows the program for NodeMCU.



finclude <SoftwareSerial.h>
finclude <ArduinoJson.h>
//DS = Rx & D6 = Tx
SoftwareSerial nodemcu(D5, D6);
void send_data() {
 StaticJsonBuffer<200> jsonBuffer;
 JsonObject& data = jsonBuffer.parseObject(nodemcu);
 if (data == JsonObject::invalid()) {
 Serial.println("Invalid Json Object");
 jsonBuffer.clear();
}



Figure 4.6 Coding for NodeMCU

4.4 Analysis

To make sure I-SIRAM is relevant to community, a few of statistical analysis is important to carried out the project. The statistical analysis is done through research and findings.

4.4.1 Analysis Based on Temperature

This analysis is to show the relationship between temperature and the voltage generate by the solar panel. In Malaysia, the average normal temperature is between 21°C to 32°C. the solar panel's output current grows exponentially as its temperature rises, but its voltage output decreases linearly. As a result, heat can significantly lower the solar panel's ability to generate electricity. Graph below shows the relationship between voltage and solar panel temperature.



Figure 4.7 Voltage vs Solar Panel Temperature

4.5 **Performance Analysis**

As mentioned in the previous discussion, the water pump will be activate when the EC value is less than 4 mS/cm. This is because it is suitable EC value for plant. The water pump will only activate when both peristaltic pump is activated. Table 4.1 below shows the performance analysis of this project.

| Peristaltic Pump A | Peristaltic Pump B | EC value | Water Pump |
|--------------------|--------------------|----------------------------------|------------|
| MAL | YSIA 4 | | |
| On HERRIC | On | 1:31.31 PH:6.193 EC:3.71ms/cm | On |
| ا مارك | يكل مليس | T:31.31 PH:6.313 EC:4.48ms/5m | Off |
| UNIVER | SITI TEKNIKAI | - MALAYSIA MEI | LAKA |
| On | Off | T:31.31 PH:6.193 EC:3.71ms/cm | Off |
| On | Off | T:31.31 PH:6.313 EC:4.40ms/cm | Off |

| Ta | ble | 4.1 | Per | form | ance | Ana | lysis |
|----|-----|-----|-----|------|------|-----|-------|
|----|-----|-----|-----|------|------|-----|-------|

| Off | On | T:31.31 PH:6.193 EC:3.71ms/cm | Off |
|-----|-----|--|-----|
| Off | On | T:31.31 PH:6.313 EC:4.40ms/cm | Off |
| Off | Off | Either the value is less or more than 4 mS/cm | Off |

4.6 Summary

As a summary, I-SIRAM is a smart system fertigation as it makes use of technology to apply fertilisers for plant. In this system, the user can monitor the plant's nutrient requirements and modifies the fertilisation as necessary using sensors and controllers. The user can monitor the fertilisation levels using I-SIRAM when it is connected to a main computer or smartphone. Additionally, it can be set up according to our desired value of EC meter and other variables. I-SIRAM can save time by eliminating the need for manual fertilisation. By giving plants the precise quantity and timing of nutrients that they require, it can also increase crop yields. This project uses sensors to track EC meter, pH value, temperature, and adjust the fertiliser as necessary.

As a result, I-SIRAM is a sophisticated fertigation system that employs technology to deliver fertilisers to plant based on their unique nutrient requirements and other factors. It can increase crop yields while saving time and resources.

CHAPTER 5

CONCLUSION

5.1 Conclusion

In this project, an affordable fertilization system using Arduino an IoT is build. The gross cost to build the system is not more than RM 600. The cost is suitable for a house to use I-SIRAM with slogan "1 House, 1 I-SIRAM".

Next, with the enhancement of technology, I-SIRAM was able to analyse the measurement of fertilization system based on pH value, EC meter, and temperature through smartphone. By using IoT, with the help of NodeMCU, user can monitor the three parameters and measure the right amount of EC to give it to the plant. With the aid of peristaltic pump, fertilizer A and B is mix up to give enough nutrient for plant. As a result, all the performance of transmission of the sensor's data to the cloud is done in real time.

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Through the finding, I-SIRAM can be used to save energy and time for the user. For example, the user can water and fertilize their plant by using one click through their smartphone. It is very convenient and suitable to be installed at any house. User also can monitor their fertilizer through temperature and pH value. These two parameters are important to make sure that the fertilizer is in good condition. Normally, based on conducted experiment, the optimal value of EC will decrease when the temperature increase [5]. Because of that, temperature is one of the most important factors to be considered. The pH value in fertilizer indicates the amount of hydrogen ion. If the hydrogen is increase, then the fertilizer will become acidic and vice versa [6]. Based on research, hydrogen can be resulting in increased the ability of plants to withstand

environmental stresses like drought, salinity, cold, and heavy metals [7]. Therefore, it is necessary to add these two parameters to be monitored by the user.

5.2 Future Works

I-SIRAM with a slogan "1 House, 1 I-SIRAM" is a good product to be installed in each home. But there is a few improvements that can make this project convenient to use. Firstly, soil moisture sensor can be used to water the plant. In this project, user don't have option to water their plant because I-SIRAM is focusing more on fertilizer. When soil moisture sensor is used, it can detect the soil water content. If the moisture is low, it can trigger motor pump to water the plant. With this improvement, user can save time to water their plant every day. Also, the use of water can be saved because it will water the plant until the soil moisture reach the desired value.

I-SIRAM also can be improved by using timer in the system and make it as fully automated fertigation system. For example, a plant needs to be fertilize three times a day so the user can put their desired time to fertilize their plant. With this feature, user can save a lot of time and energy to take care their plant. For instances, system can be set to fertilize the plant during morning, evening, and night and the user no need to worry to fertilize their plant every day. To make this happen, the development of more effective algorithms for determining the best fertilisation schedule, improvements to algorithms for more precise monitoring of soil moisture and nutrient levels need to be done. The creation of more effective and affordable methods to feed nutrients to plants are all potential future developments for smart system for fertigation. Additionally, there is active research into the application of Machine Learning and Artificial Intelligence (AI) to optimise fertigation and boost crop yields.

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