iJournals: International Journal of Software & Hardware Research in Engineering
ISSN:2347-4890, ijournals.in/ijshre
Volume 12 Issue 7, July 2024

IOT Based Smart Irrigation System Using Solar Energy

Authors: Hussam M Jokhab; Ahmed Abouelfadl[1]; F. S. Alhosarey[2]; Mohamed E. Dessouki [3]

King Abdulaziz University, Faculty of Engineering Rabigh, Electrical Eng. Department

abouelfad@kau.edu.sa[1]; falhosarey@kau.edu.sa[2]; maboelmorsy@kau.edu.sa[3]

DOI: 10.26821/IJSHRE.12.7.2024.121101

ABSTRACT

Many people around the world depend on agriculture, as it is the main source of food. With the advancement of science, many techniques have spread that work well on agricultural production. Therefore, the smart irrigation system is a modern technology that contribute to monitoring the condition of the fields.

IOT Based Smart Irrigation System Using Solar Energy can give as many advantages such as real time feedback and this system can save us time and effort[1,2].

The ESP32 is an affordable and energy-efficient series of microcontrollers that operate as system-on-a-chip (SoC). These microcontrollers come equipped with integrated Wi-Fi and capabilities, offering a highly integrated structure for diverse applications. Because of the hard environment in Saudi Arabia and lack of the rain in most of the regions and the limited water sources it's hard to farm and maintain the plants or plant all the cities the entire year, also the distance between agricultural areas and residential areas.

On this paper we design and implement an IOT based smart irrigation system using solar energy to achieve many goals like: raising the efficiency of agriculture, treating water scarcity, making farming easy and simple, and using clean energy. This system collects data from wireless sensors measuring soil moisture using IOT and controls the irrigation pumps. The pumps are monitored and protected using sensors. Also, the whole system is monitored and protected from human's or animals' attacks using motion sensor. The system is powered using solar energy system using lithium-ion battery and Pulse Width Modulation (PWM) battery charger. Finally, a mobile application is designed and implemented for monitoring the condition of the system and controlling its components.

Keywords: IOT, Solar Energy, ESP8266, Plynk App

INTRODUCTION

One goal of the Saudi Vision 2030 is the Saudi Green Initiative (SGI). The Saudi Green Initiative (SGI) is a large-scale national ambitious aimed at preventing climate change and increasing quality of life, as well as preserving the natural environment for future generations. Introduced in 2021, SGI is a national endeavor that unites all sustainability initiatives to expeditiously increase the Kingdom's climate action. SGI is driving Saudi Arabia's shift to a green economy and supports the country's goal of reaching net zero emissions by 2060 through the Circular Carbon Economy approach.

we can save the customer a lot of money either by reducing the water used for watering the plants, this will cause less water bills, or by reducing the number of employees, also this project uses the clean energy (solar panels) which will power the system without electricity bills, so this project will save a fortune for long terms.

We can increase the efficiency of cultivation and ease of use for the farmer, as it makes it easier for you to schedule watering the plants and monitor the percentage of moisture in the soil and the amount of water.

Also, we are working on the ease of implementing agriculture anywhere and anytime, and agriculture becomes easy and simple, and it is possible for all people to become farmers, and it is possible to benefit from this idea in the future and to be addressed in the hands of everyone as it motivates everyone to farm, and it enhances the Kingdom's vision to make agriculture a priority.

1. SOLAR ENERGY SYSTEM

The solar energy system consists of solar panels, batteries and battery chargers.

1.1. Solar Photovoltaic Panel

Solar energy depends on sunlight and is used to convert sunlight, which consists of energy molecules (photons) into electrical energy. There are three types of solar panels that differ in shape, characteristics, installation, cost, and appropriate efficiency as shown in Fig. 1.

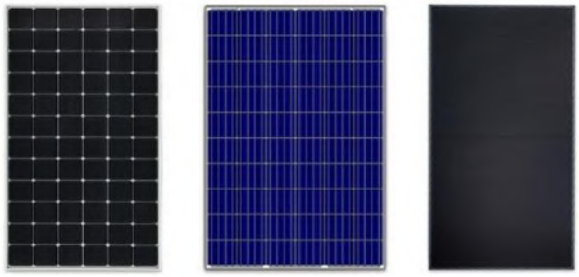


Fig. 1: Types of solar PV panels.

2.1.1 Polycrystalline PV Panels

The solar panels have many silicon crystals arranged in a single photovoltaic cell. The silicon shards that make up polycrystalline solar panel wafers are fused together.

2.1.2 Monocrystalline PV Panels

PV solar panels with a single crystal. They are constructed from a single, pure silicon crystal that has been divided into several wafers. These chips have a distinctive shape and a consistent color since they are sliced into an octagonal shape. They are easily identified by their black or dark blue appearance, which indicates that they are constructed of pure silicon.

2.1.3 Thin-film PV panels

This type of solar panel is lightweight and flexible, which helps in its installation on any surface used due to its low cost.

Comparison between the PV panels is presented in Table 1.

Table 1. Comparison between the PV panels.

Types	Efficiency (%)	Cost	Life
Polycrystalline	11-14%	Medium	25-35
Monocrystalline	12.5-15%	High	25-40
Thin film	10-13%	Low	10-20

1.2. Solar Charge Controller

The charging regulator is crucial in organizing and enhancing the voltage and current coming from the solar panels to values that are compatible with the system voltage (battery voltage and input voltage for inverters), and it also works to charge batteries in stages by performing fast charging first and then gradient to reduce the value of the charging current as the batteries approach full capacity while also protecting batteries from overcharging.

The most important functions of the solar charge regulator: regulates the charging of electric batteries, protects batteries from full discharge, protects solar panels from back current, and monitors the status of batteries with the regulator.

2.2.1 PWM Charge Controller

The term "Pulse Width Modulation" is an acronym for this technique, which lowers the voltage coming from the panels to a voltage compatible with the voltage of the batteries. As a result, it has the disadvantage of not utilizing the remaining energy when shrinking, which lowers the system's efficiency. Additionally, you cannot install panels in a row because we want the voltage of the panels to be close to the voltage of the regulator to utilize as much energy as possible.

2.2.2 MPPT Charge Controller

Maximum Power Point Tracking" is the term used to describe this type of solar energy system. It is produced using better technologies than the PWM type, making it acceptable and excellent for medium and large solar energy systems because it uses all the energy produced by solar panels without experiencing nearly any loss, regardless of the weather. You can also install panels in series as long as you stay within the regulator's specified voltage range. However, the disadvantage of this type is its high cost.

1.3. Batteries

There are several batteries with different capacities and high voltages, but based on the requirements for the project, we determined that the battery should not be less than 12 volts, which is considered the maximum voltage we need.

2.3.1 AGM:

(Absorbent glass mat): It consists of very thin layers of anti-vibration insulators. The method of charging it is to connect the electrical voltage to the battery terminals so that the current flows through the battery, then it undergoes a chemical reaction of the electrolyte

with the lead strips, then it stores and uses the energy. What distinguishes it is that it is suitable if you want to transport it. It is often used in rugged areas due to its resistance to leakage [3].

2.3.2 Gel battery

It contains lead mixed with a liquid substance that becomes like jelly and is called silica. It is charged by applying electrical voltage to both ends of the battery, and during the charging process gas comes out of the gelatinous material in a small percentage. Its discharge is very low, which gives us a longer period to store energy in it. What distinguishes it is its resistance to different temperatures, which is why it is considered common in solar energy systems [3].

2.3.3 lithium-ion battery

It consists of lithium ion, where the lithium moves between the anode and cathode during the charging and discharging process. This type is distinguished by its unique design from other batteries. It is lightweight and small and has space to store a large amount of energy. Its discharge rate is very low, as it is possible to store energy in it. For a very long time [3].

2. IOT COMPONENTS AND SENSORS

The Internet of Things (IoT) is a network of interconnected devices that exchange data with each other and the cloud. IoT devices are embedded with sensors and software, serving a wide range of applications in various industries. This technology enables data transfer without direct human involvement and can include objects like wearable health devices, livestock tracking chips, and smart vehicles. IoT offers opportunities for increased efficiency, better customer service, data-driven decision-making, and business value. However, it also raises concerns about data security and privacy.[4]

2.1. Arduino Mega

Arduino is a programable device that can read many input data such as measuring a moisture level in a plant and then, do the programmed command as an output such as watering the plant if there is not enough water [5]. There are many reasons to prefer using Arduino the other platform. Arduino is not expensive device and it cost about 20 dollars, the programming application is available in all the platforms such as windows and it is easy to program for all users.

There are different types of Arduinos with different functions such as: Arduino UNO, Arduino Micro, Arduino Nano and Arduino Mega.

Arduino Mega has been chosen because it has many advantages such as: it has more input and output pins, many ways to power the Arduino and it is better to program complex projects.

2.2. Esp module

a Wi-Fi module built by Espressif Systems. This module make the Arduino connect to Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. And There are several types of modules. In this paper we use ESP8266 module with the pin layout shown in Fig 2. The Esp module isn't restricted solely to connecting to Wi-Fi networks and transferring data to the internet; it also has the capacity to form its network. By serving as an Access Point (AP), it can autonomously create a network and permit other devices to link up with it. To do that There is two ways, one is using LUA scripting and other is with the Arduino IDE and serve up web pages to any connected client.[6]

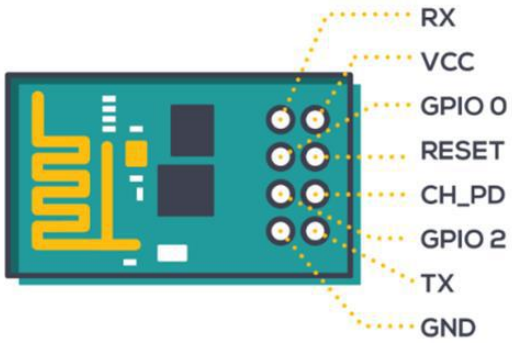


Fig. 2: ESP8266 pin layout.

2.3. GSM module

The SIM900 module, shown in Fig 3, is a standalone device that interfaces with microcontrollers via UART. It requires a SIM card for network access. It registers with a GSM network, enabling voice calls and SMS using AT commands. It also supports GPRS for internet connectivity, and with GPRS, it can establish TCP/IP or UDP connections for real-time data exchange. This makes it suitable for various communication and IoT applications.[7]

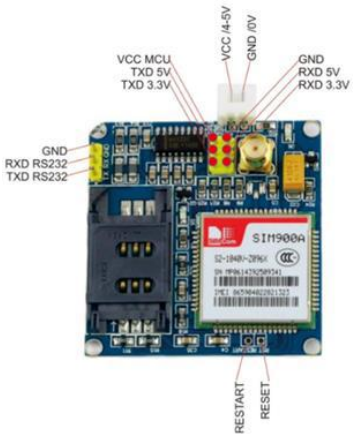


Fig 3: GSM module

2.4. Sensors

There are three types of sensors used in this paper:

- soil moisture sensor to measure the moisture content of the soil.
- ultrasonic sensor for water level.
- Motion sensor for protection.

3.4.1. Resistive soil moisture sensor

Resistive soil moisture sensor is shown in Fig 4. The two sensors measure resistance and thus we can measure the humidity. The method of operation is simple: the higher the moisture content, the more electrically conductive the soil becomes. The resistance will become lower, and as the soil dries it will no longer be able to conduct electricity, and the resistance will become higher. It will send a signal to pump water when the resistance is higher.[8]

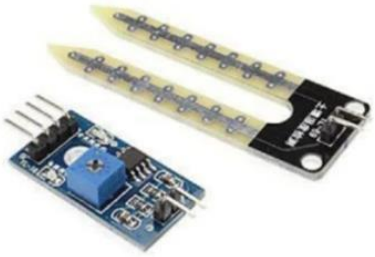


Fig. 4: Resistive soil moisture sensor.

3.4.2. Ultrasonic sensor for water level

A sensor shown in Fig 5 that works on the sound frequency for measuring the water depth in the channel and tank sources for irrigation. The types range according to the desired frequency, as there are sensors that reach a depth of 4 meters or up to a depth of 20 meters.[9]

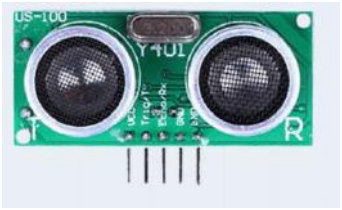


Fig. 5: Ultrasonic sensor.

3.4.3. PIR Motion sensor

The PIR sensor works to measure the temperature of objects, such as humans and animals, across its range of vision. Inside the thermal sensor, there is a pyroelectric sensor that works to determine infrared radiation. The sensor consists of a crystalline material that generates a voltage when it is exposed to infrared radiation.[10]

Fig. 6: PIR motion sensor.

3. SYSTEM OPERATION AND IMPLEMENTATION

3.1. System flowchart and operation

The proposed system operation is shown in the flowchart presented in Fig 7.

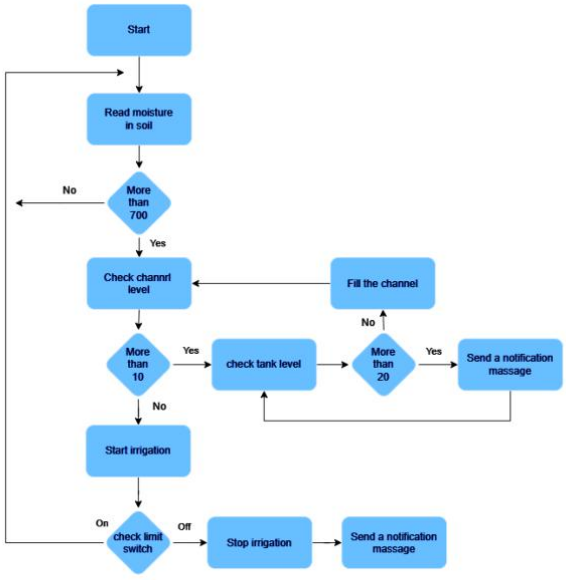


Fig. 7: System operation flowchart.

The system starts by measuring the soil moisture using the soil moisture sensor. If the soil moisture value less

than the threshold level which is selected according to the plant type, the Arduino checks the water level in the channel sources for irrigation using ultrasonic sensor. If the channel water level is below the threshold value the Arduino checks the water level of the tank souse used to fill the channel. Arduino sends ON signal to the irrigation pump if the channel water level is ok. The pump will be turned OFF if the soil moisture value reaches the suitable level for the plant. The soil moisture value and pumps states are continuously sent to the mobile application through the ESP8266 module. We can also operate the system remotely through the application by turning the pumps ON and OFF as we need.

An attack worring notification is sent to the mobile application and inplace alarm is fired if the PIR motion sensor is activated. Also, SMS messages are sent to the mobile phone of the owner with the mobile application notifications. The solar panel can be cleaned manually using pushbutton or remotely through the mobile application to improve the power efficiency.

3.2. System simulation

Every project must be tested in a simulation app, in this case Proteus 8 software package is used, to test all the equipment and coding, the programming application is [Arduino IDE], after making sure that all the equipment and coding working properly then you can start with the real prototype, finally here the simulation of the project in Proteus 8 is shown in Fig 8.

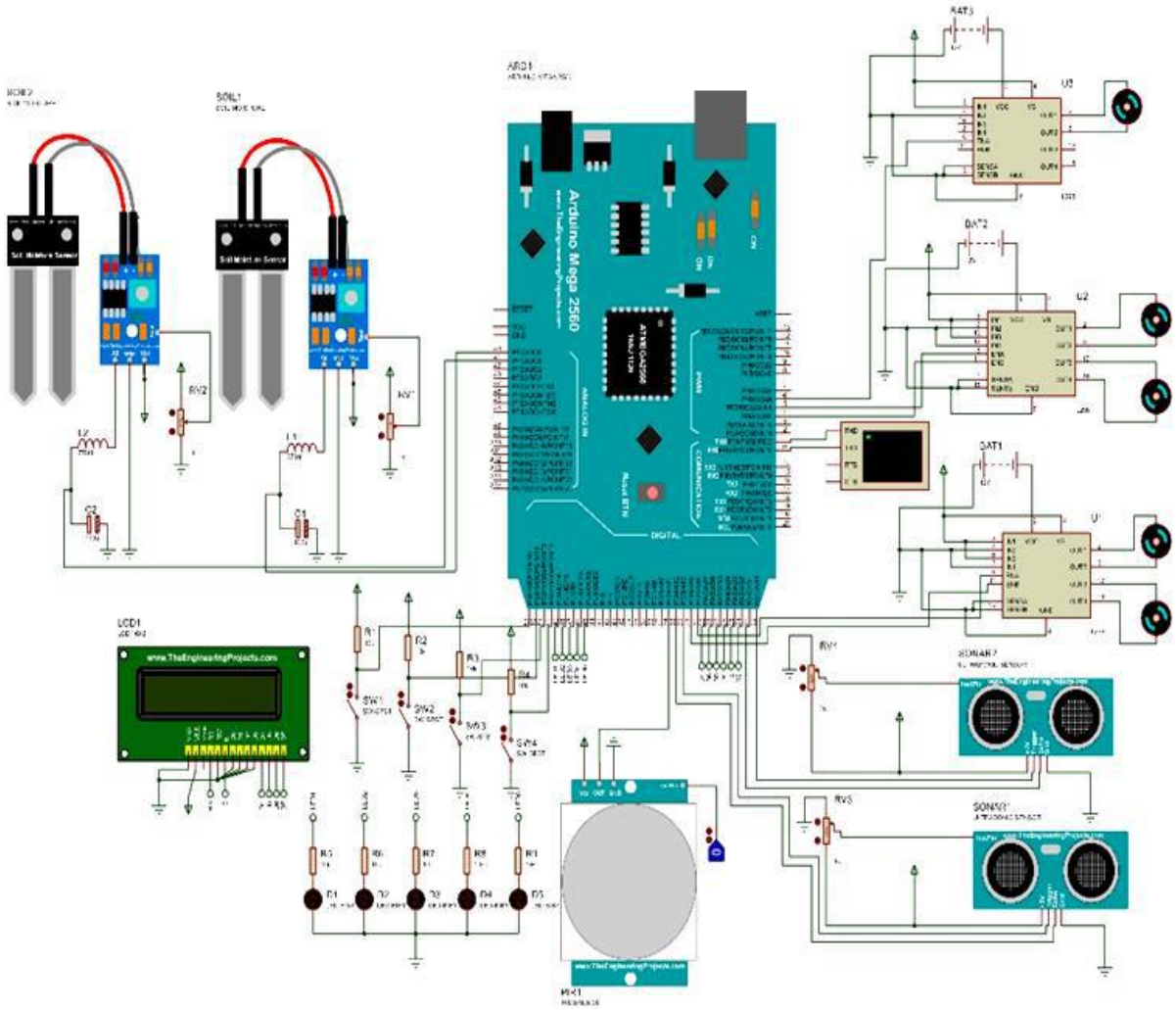


Fig 8: System simulation using Proteus 8 Software

3.3. System implementation

Initially, we designed the prototype using SolidWorks, The Solidworks program is a program used for drawing in engineering projects. It can show the 3D design of your project. The Solidworks program was used to design the system prototype as shown in Fig 9. Fig 10 shows the top view of system.

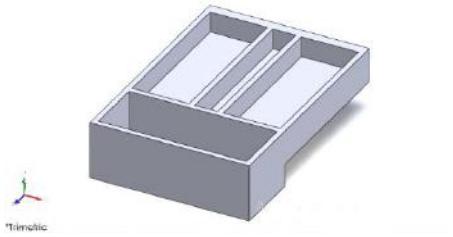


Fig 9: System prototype using Solidworks software.

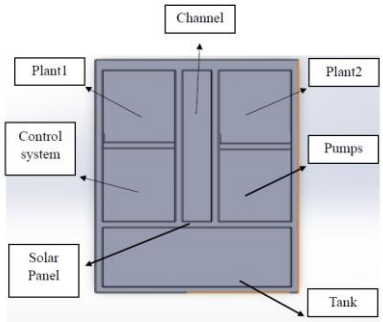
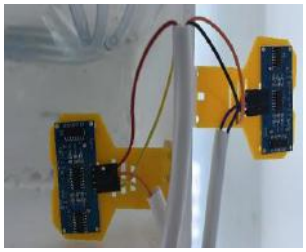


Fig 10: Top view of system prototype.

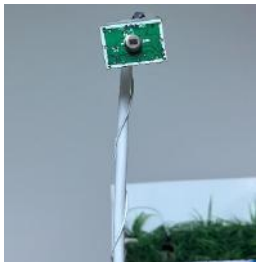
Fig 11 shows the solar panel and sensors and the electrical components of the prototype are shown in Fig 12.

(a) Solar panel



(b) ultrasonic sensors

(c) Soil moisture sensor



(d) PIR motion sensor

Fig 11 Solar panel and sensors.

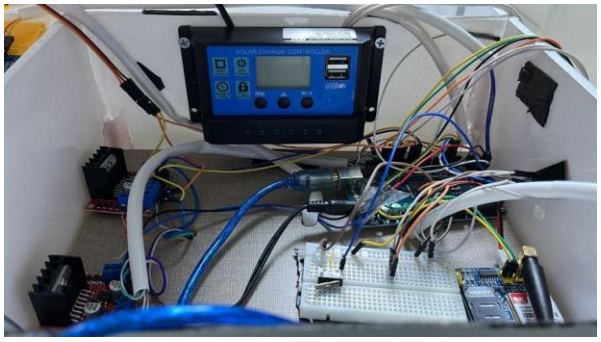


Fig 12: Electrical components of the system.

The final form of the entire proposed system is shown in Fig 13.

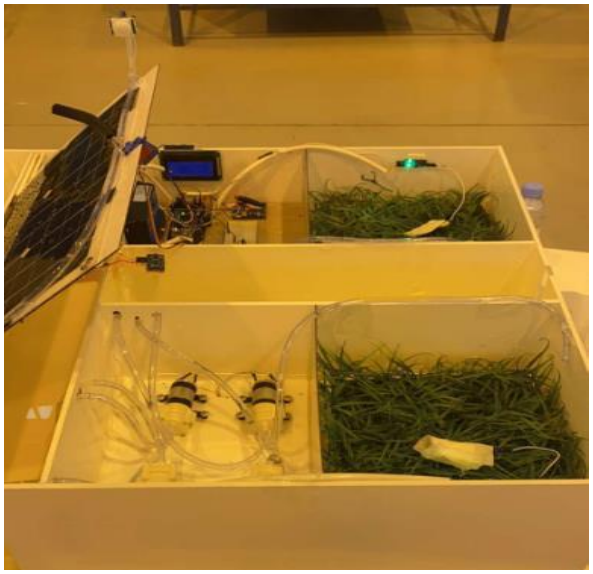


Fig 12: The final form of the entire system.

3.4. Mobile Application

Blynk App is a mobile application that provides a user-friendly interface for monitoring and controlling the IoT project. It displays real-time data collected from the sensors connected to the Arduino. Also, it allows users to send commands to the Arduino through the ESP8266 module to perform actions like turning ON/OFF devices. The mobile application layout is shown in Fig 13.

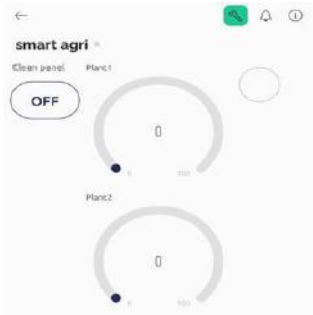


Fig 13: The mobile application layout.

We have two gauge to know the moisture level and a button to operate the solar panel cleaning system.

5. CONCLUSION

This paper successfully demonstrates the integration of IoT with smart irrigation systems powered by solar energy. The system, comprised of Arduino, ESP8266, and the Blynk app, allows for efficient and remote monitoring and control of irrigation schedules, thereby optimizing water usage and supporting sustainable agricultural practices. Additionally, the incorporation of SMS notifications using Arduino and the GSM900 module enhances the system's reliability by providing real-time feedback and alerts, ensuring timely interventions when necessary.

6. REFERENCES

[1] M. Bhattacharya, A. Roy and J. Pal, "Smart Irrigation System Using Internet of Things," Applications of Internet of Things, p. 119–129, 2021.

[2] Y. Shekhar, "Intelligent IoT based automated irrigation system," International Journal of Applied Engineering Research, vol. 12, p. 7306–7320, 2017.

[3] C. Masquelier and J.-M. Tarascan. edited Lithium-Ion Batteries: Advances and Applications 2018.

[4] Mansaf Alam ,Kashish Ara Shakil ,Samiya Khan Editors ,Internet of Things (IoT) Concepts and Applications,2020

[5] Designing Embedded Systems and the Internet of Things (IoT) with the ARM® Mbed™ ,Perry Xiao London South Bank University UK ,2018

[6] Internet of Things: Theory to Practice, Pramod R. Gunjal, Satish R. Jondhale, Jaime Lloret Mauri, Karishma Agrawal ,CRC Press, 2024

[7] HANDS-ON ESP32 WITH ARDUINO IDE,Asim Zulfiquar ,Packt Publishing Ltd., Birmingham, UK, 2024

[8] Gabriela Civeira Editor soil moisture 2019.

[9] Mubina Toa, Akeem Whitehead Editors, Ultrasonic Sensing Basics,2021.

[10] Passive Infrared Detection Theory, Applications, by joseph caniou,2013.