ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24APR1734

Solar-Powered GSM Irrigation for Intelligent Water Management

Yalagala Sathwik Patel[1]; Tekumalla Shiva Sai[2]; Ramadasu Sumanth[3] and Dr. A.N.Satyanarayana[4]
[1,3]Students of B.Tech, ECE Department, Sreenidhi Institute of Science and Technology, Hyderabad
[4]Professor of ECE Department, Sreenidhi Institute of Science and Technology, Hyderabad

Abstract:- Efficient water management is crucial for sustainable agriculture and landscaping. This project introduces a novel solution, combining solar power and GSM technology to create an intelligent irrigation system. Integrated GSM connectivity enables remote monitoring and control, allowing users to adjust irrigation schedules and settings from anywhere, enhancing convenience and flexibility. By leveraging data analytics and sensor feedback, the system optimizes water usage, ensuring precise delivery based on plant needs and environmental conditions. This approach not only conserves water but also promotes healthier plant growth and higher yields. The integration of GSM technology ensures real-time communication and alerts, allowing users to respond promptly to changing conditions and unforeseen events. Through case studies and performance evaluations, the presentation will demonstrate the system's reliability, durability, and cost-effectiveness, underscoring its viability for widespread adoption. Attendees will gain insights into how solar-powered GSM irrigation can revolutionize water management practices, empower farmers and gardeners, and contribute to building resilient, sustainable ecosystems in a rapidly changing world.

Keywords:- *Soil Moisture Sensors; GSM Module; ESP 32; GPS Module; Solar Power; Voltage Sensors.*

I. INTRODUCTION

The increasing global demand for sustainable energy solutions, coupled with concerns over fossil fuel depletion and environmental degradation, has underscored the urgency of exploring alternative, renewable energy sources. Solar power, with its abundance and environmental friendliness, has emerged as a viable option for powering various applications, including smart irrigation systems.

In this paper, we propose a novel smart irrigation system that harnesses solar energy, incorporates a GSM module, and utilizes the ESP32 microcontroller. Our system represents an integration of cutting-edge technology aimed at efficiently managing water resources for agricultural purposes.

By leveraging solar energy to drive the irrigation system, we aim to reduce reliance on non-renewable energy sources while minimizing carbon emissions and noise pollution typically associated with conventional diesel-powered pumps. The inclusion of a GSM module and ESP32 microcontroller enables remote monitoring and control of the irrigation system, enhancing its functionality and accessibility. Through this innovative integration, users, particularly farmers, can remotely adjust irrigation schedules, monitor soil moisture levels, and optimize water usage, thereby potentially improving crop yields while conserving vital water resources. Moreover, our system seeks to address practical challenges encountered in agricultural settings. By providing an efficient, sustainable, and cost-effective solution, our solar-powered smart irrigation system holds promise for enhancing agricultural productivity and promoting environmental sustainability.

The proposed project addresses three critical concerns in modern agriculture. Firstly, it incorporates a sound alarm system to detect intruders on the farm, whether they are humans or animals. Secondly, the project aims to protect crops from rain damage by efficiently recycling rainwater for irrigation.

Thirdly, it focuses on smart irrigation, achieved through sensor interfacing, Wi-Fi modules, and GSM technology. This comprehensive solution aims to reduce water wastage, minimize human effort, and provide real-time field information to farmers via their mobile devices. The smart irrigation system is firmware-based, as depicted in Figures of the project system configuration.

Objective: The main goal of integrating solar-powered smart irrigation systems is to enhance agricultural water management by leveraging technology to monitor soil moisture, weather patterns, and plant requirements. This strategy aims to boost crop productivity, conserve water resources, and minimize reliance on convenient energy sources, fostering sustainable farming practices.

II. METHODOLOGY

Our approach to developing a smart irrigation system Centre around the seamless integration of an ESP32 microcontroller and a GSM module. This meticulously designed system architecture aims to optimize water management in agricultural contexts. Our process begins by strategically deploying soil moisture sensors across the irrigation field. These sensors communicate with the ESP32 microcontroller, providing real-time data on soil moisture levels. The ESP32 then analyzes this data against predefined

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24APR1734

thresholds to determine optimal irrigation schedules and regulate waterflow.

Additionally, we incorporate a GSM module into the ESP32, enabling remote monitoring and control of the irrigation system. Users can adjust settings—such as system activation, deactivation, and irrigation schedules—via SMS commands or a dedicated mobile application. To enhance usability, we have developed a user-friendly interface that allows real-time sensor data viewing and status notifications. To validate its effectiveness, we conduct comparative analyses between our smart irrigation system and traditional methods. The advantages of our system become evident, including improved efficiency and resource conservation. By leveraging advanced technologies, our solution contributes to sustainable water management, benefiting both agricultural productivity and environmental well-being problems.

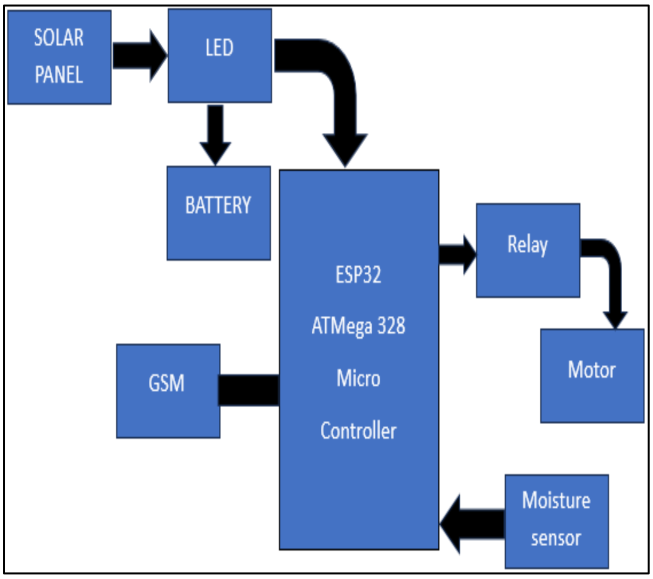

Fig 1 Flow Chart of Smart Irrigation System

A. Components

➢ *Soil Moisture Sensor*

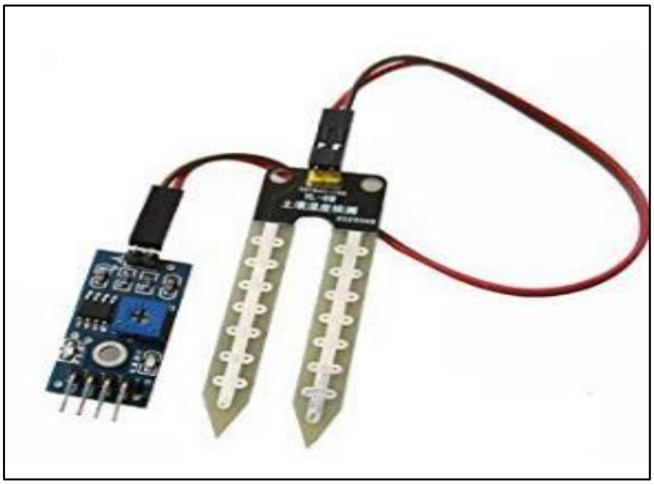
Fig 2 Soil Moisture Sensor

In Figure 2, we observe soil moisture sensors, which serve as essential devices for measuring volumetric water content. These sensors convert physical parameters into electrical signals, enabling the detection of moisture levels within the soil. Their role is critical in efficient water management.

➢ *ESP32-Node MCU*

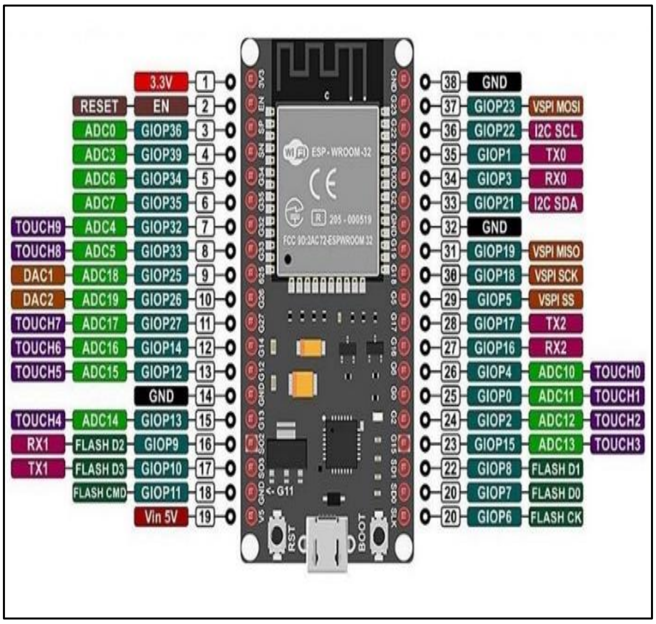
Fig 3 ESP32

The ESP32 microcontroller, a versatile embedded system, serves as the backbone of our smart irrigation project. Its low-power operation ensures efficient energy usage, crucial for prolonged operation in agricultural settings. With built-in Wi-Fi and Bluetooth connectivity, the ESP32 facilitates seamless communication with sensors and the GSM module, enabling remote monitoring and control. Additionally, its ample processing power allows for real-time data analysis, optimizing irrigation scheduling based on soil moisture levels. Versatile GPIO pins enable easy integration with various sensors, offering flexibility and adaptability to different agricultural environments.

➢ *GSM Sim*

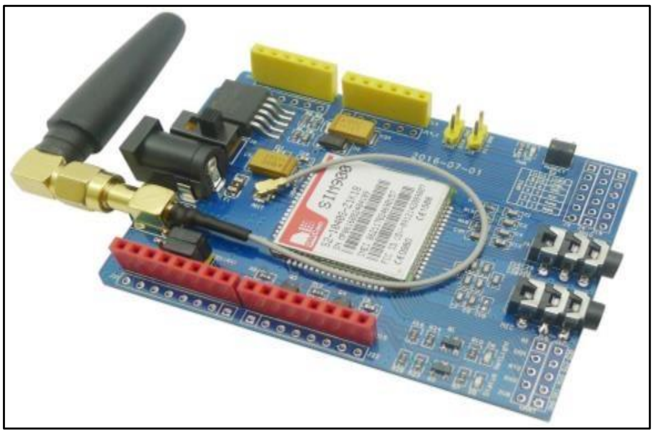
Fig 4 GSM Sim

Depicted in Figure 4, GSM stands for Global System for Mobile Communication and operates under the research standards denoted by GSM 802.11. The GSM Sim 900, utilized in our project, serves as a digital transmitting and receiving device designed for open-air cellular mobile communication. It plays a pivotal role in establishing communication between the user (farmer) and the system, facilitating long-distance control and monitoring capabilities.

➢ *LCD*

Fig 5 LCD

Described in Figure 5, a serial computer bus serves as a compact interface utilized to connect lower-speed peripheral integrated circuits (ICs) to processors and microcontrollers. In our project, this bus plays a crucial role in facilitating the connection between the LCD display and the ESP32 microcontroller.

➢ *Solar Panel*

As illustrated in Figure 6, a solar power panel functions as a device that directly converts sunlight and temperature into electrical power. In our project, we utilize a PV panel with dimensions measuring 185*250*15 mm and a power output of 5W. To optimize power generation, an MPPT controller is employed, ensuring the panel operates at its maximum efficiency level.

Fig 6 Solar Panel

➢ *DC Water Pump*

Fig 7 DC Water Pump

Depicted in Figure 7, a DC water pump is employed to transfer water from one location to another efficiently. This specific pump operates at DC 12V, with a power rating of 4.2W and a maximum flow rate of 204 liters per hour (Qmax: 204L/H).

➢ *Relay*

Fig 8 Relay

For a Figure 8, showcases an electrically operated device utilized to regulate the operation of the water pump in our project. In solar-powered smart irrigation systems, relays are pivotal for integrating renewable energy with precise water distribution. These relays, utilizing solar panel output, regulate valves and pumps to optimize irrigation efficiency. Their control allows for dynamic adjustments based on environment factors and crop requirements, enhancing agricultural productivity.

III. IMPLEMENTATION & RESULTS

In the implementation of the ESP32 microcontroller for the smart irrigation system, its primary function revolves around sending status messages indicating soil moisture levels and irrigation system operation. The ESP32 is programmed to monitor soil moisture data from sensors and relay this information via SMS messages using the GSM module.

Upon receiving data from soil moisture sensors, the ESP32 evaluates the moisture levels and determines the system's operational status. If soil moisture levels indicate dry conditions, the ESP32 generates a message indicating the

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24APR1734

need for irrigation ("Dry: Initiate irrigation"). Conversely, if moisture levels indicate adequate soil hydration, the ESP32 sends a message confirming the system's standby state ("Wet: Irrigation not required”).

Furthermore, the ESP32 oversees the operation of the irrigation system, toggling the water pump on or off based on predefined moisture thresholds. When initiating irrigation, the ESP32 sends a message indicating the activation of the water pump ("Pump: ON"). Conversely, upon completion of irrigation or when soil moisture levels reach optimal levels, the ESP32 sends a message confirming the deactivation of the water pump ("Pump: OFF”).

This implementation ensures efficient communication of crucial system status updates to the user, facilitating timely intervention and maintenance of optimal soil moisture conditions. Through its integration with the GSM module, the ESP32 enables remote monitoring and control of the smart irrigation system, enhancing its usability and effectiveness in agricultural settings.

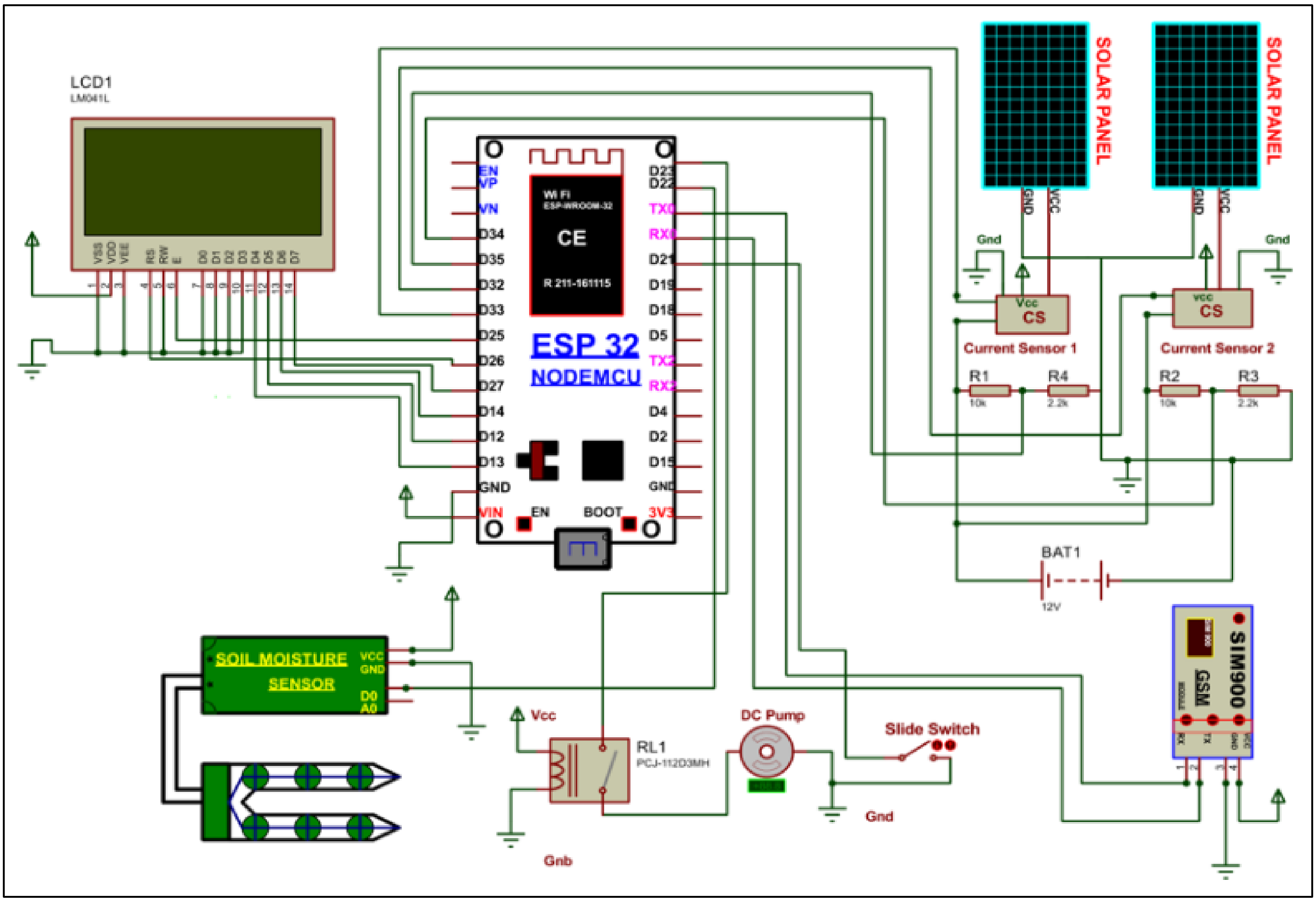

Fig 9 Experimental Setup of Smart Irrigation System

Expanding on the functionality of our smart irrigation system, the ESP32 microcontroller facilitates seamless integration with mobile devices, enabling users to remotely control the irrigation system via a dedicated mobile application. Through the mobile application, users can initiate irrigation cycles, toggle the water pump on or off, and switch between manual and automatic operation modes. In manual mode, users have direct control over the irrigation system, allowing them to activate or deactivate the water pump as needed. This mode is particularly useful for quick adjustments or troubleshooting tasks, providing users with flexibility and control over irrigation operations.

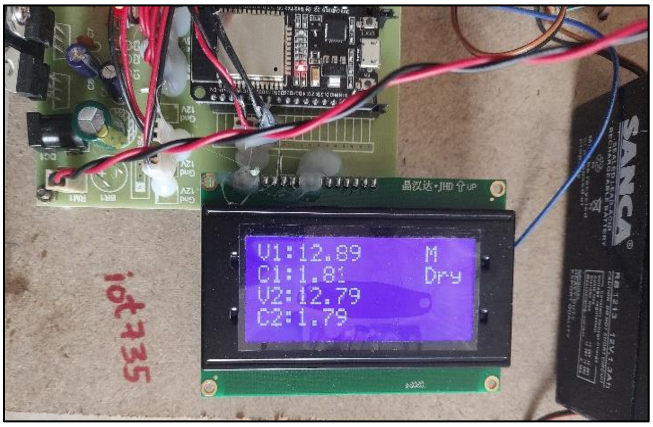

Fig 10 LCD Screen Show the Sensors Reading and the Voltage Levels

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24APR1734

Conversely, in automatic mode, the ESP32 microcontroller autonomously regulates irrigation cycles based on predefined soil moisture thresholds. Users can set these thresholds through the mobile application, defining the desired moisture levels for initiating and terminating irrigation cycles. Once configured, the ESP32 continuously monitors soil moisture levels and activates the water pump when moisture levels fall below the specified threshold. This automated process ensures efficient water management while minimizing manual intervention.

Furthermore, the mobile application offers additional features to enhance user experience and system functionality. Users can access real-time data on soil moisture levels, receive notifications and alerts regarding system status, and customize irrigation schedules based on specific crop requirements. Additionally, the application may include intuitive graphical interfaces for visualizing historical data trends and analysing irrigation performance over time.

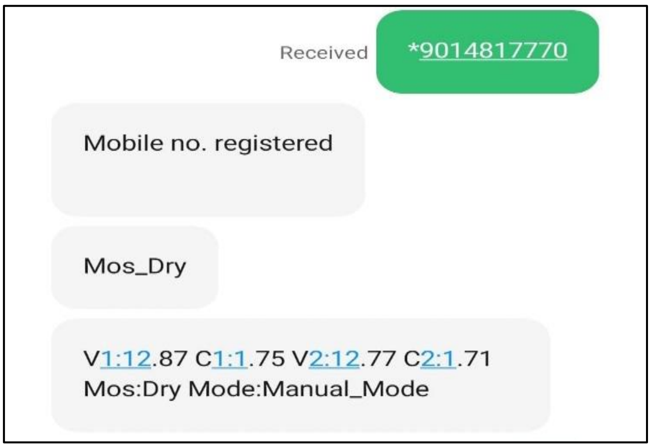

Fig 11 User Gets the Message

Through seamless integration with mobile devices and customizable operation modes, our smart irrigation system powered by the ESP32 microcontroller offers a comprehensive solution for efficient water management in agriculture. By combining remote control capabilities with automated irrigation algorithms, the system enables users to optimize water usage, enhance crop yields, and promote sustainable agricultural practices.

IV. CONCLUSION

In conclusion, the objective of this project is to enhance efficiency in time, cost, and water consumption by implementing a smart irrigation control system powered by solar energy. This study holds significance within the energy and environmental sectors. The irrigation control system was meticulously designed, implemented, and successfully met the research objectives. Sensing soil moisture levels through soil moisture sensors. Displaying voltage data from the sensors on an LCD Screen.

Programming the ESP32 microcontroller and connecting it with mobile phones to enable automatic irrigation system control. Notifying users via smartphone notifications when the soil moisture levels indicate dryness or moisture, enabling automatic activation and deactivation of the water pump for plant irrigation. This smart irrigation control system proves advantageous in regions facing water scarcity, lack of access to electrical grids, and expansive agricultural lands.

FUTURE SCOPE

Since the scope of the project was using the water pumping system for irrigation and control this system by microcontroller, there are extra things could be added to improve this project. A water level sensor could be added to irrigate the land with the suitable amount of water. Also, noise sensor could be added to protect the farm field from the animals or even human get closer to the farm by producing a noisy sound as an alarm or buzzer.

An additional enhancement for this project involves incorporating electronic gate valves. This feature becomes essential when multiple farms require individual irrigation at different times, all managed by a single system (as depicted in Figure 12). Each land area should have its dedicated soil moisture sensors connected to the controller as inputs. Simultaneously, electronic gate valves would be linked to the controller as outputs.

This integration allows precise control over water flow to specific fields, optimizing irrigation schedules and resource utilization. An additional enhancement for this project involves providing farmers with the flexibility to control the water pump. In cases where crops are damaged or absent, irrigation becomes unnecessary even if the soil is dry. By incorporating this feature, the system can intelligently adapt to the actual crop condition.

Furthermore, expanding the system's capabilities beyond irrigation alone is crucial. We propose integrating functions such as seeding, ploughing, and fertilizing. Whether using an Arduino or a PLC as the controller, automating these agricultural tasks will enhance overall efficiency and productivity.

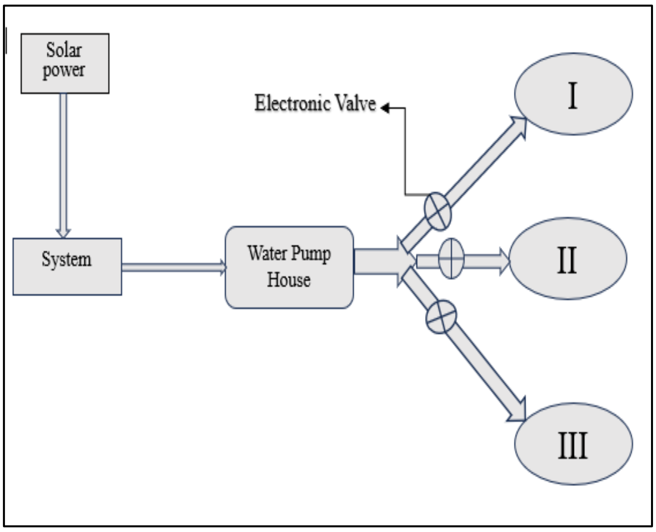

Fig 12 Irrigation System Control with 3 Valves

ACKNOWLEDGMENT

We would like to thank our project coordinator Dr. A. N. Satyanarayana, who supported us during the completion of the project and helped us a lot in developing the manuscript.

REFERENCES

[1]. Salch Elkelani Babaa, Nunner Ahmed, Babatunde Samuel Orgunleye, Salim Ahmed Al-Jahdhami, Shahid Ali khan, John Regan Pillai. (2020). Smart Irrigation System Using Arduino with Solar Power. International Journal of Engineering Research & Technology(IJERT), Volume(9), 91-97, **www.ijert.org**.

[2]. Sudharshan N, AVS Kasturi Karthik, JS Sandeep kiran, S.Geetha. (2019). Renewable Energy Based Smart Irrigation System. Elsevier B.V., 615-623.

[3]. Rashmita Mohapatra, Rushil Pathare, Vanshaj Gupta, Sreya Nair. (2023). Solar Panel Energy with Smart Irrigation System. Andalasian International Journal (AIJ), Vol 03, No. 01, 44-49, https://doi.org/10.25077/aijaset.v3i01.71.

[4]. Muhammad Aliff Bazil Bukhari, Mohd Noor Abdullah. (2022) Automated Photovoltaic Irrigation and Monitoring System with Internet of Things for Fertigation System, Evolution in Electrical and Electronic Engineering. Vol.3 No.1, 579-586, http://publisher.uthm.edu.my/periodicals/index.php/eee.

[5]. Okomba N. S., Esan, A. O., Omodunbi, B. A., Sobowale, A. A., Adanigbo, O. O. and Oguntuase, O. O. (2023). IOT Based Solar Powered Pump for Agricultural Irrigation and Control System, FUDMA Journal of Science (FJS), Vol. 7 No.6, 192-199, https://doi.org/10.33003/fjs-2023-0706-2056.

[6]. AI Abdelkerim1, MMR Sami Eusuf1,4, MJE Salami1, A. Aibinu2 and M A Eusuf3. (2013). Development of Solar Powered Irrigation System. IOP Publishing Ltd.

[7]. Zaidan Didi, Ikram El Azami. (2023). Monitoring of submersible pumps using ESP32 microcontroller and photovoltaic panels. Indonesian Journal of Electrical Engineering and Computer Science, Vol. 30, No. 3, June 2023, pp. 1470~1477, ISSN:2502-4752, DOI: 10.11591/ijeecs. v30.i3.

[8]. Ronak Ali Baladi, Madad Ali Shah. (2018). Solar Powered Irrigation System for Agriculture based on Moisture Content in the Field and Saving Energy and Water with Optimum Designing. ASIAN JOURNAL OF ENGINEERING, SCIENCES & TECHNOLOGY, VOL.8, ISSUE 1.

[9]. Alok Gora1 and M.S. Dulawat. Solar powered smart irrigation system Solar powered smart irrigation system-an innovative concept. Research Journal of Agriculture and Forestry Sciences, ISSN 2320-6063, Vol. 5(6), 15-19, June(2017).

[10]. S. Harishankar1, R. Sathish Kumar2, Sudharsan K.P, U. Vignesh and T. Viveknath. Solar Powered Smart Irrigation System. Advance in Electronic and Electric Engineering. ISSN 2231-1297, Volume 4, Number 4 (2014), pp. 341-346 © Research India Publications http://www.ripublication.com/aeee.htm.