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SMART SOLAR POWERED IRRIGATION SYSTEM USING IOT

A. Deepthi[1] | B. Somanadh Krishna Prasad[2] | K. Jagadeesh[3] | P. Bhagyaraju[4] | G. Siva Sai Ram[5]

[1,2,3,4]Students of Mechanical Engineering Department, Nadimpalli Satyanarayana Raju Institute of Technology, (NSRIT), Autonomous, Visakhapatnam – 531173.

[5]Assistant Professor, Department of Mechanical Engineering, Nadimpalli Satyanarayana Raju Institute of Technology, (NSRIT), Autonomous, Visakhapatnam – 531173.

ABSTRACT

This project develops a solar-powered, IoT-based smart irrigation system using an ESP32 micro-controller for efficient water management. Soil moisture and DHT22 sensors monitor moisture, temperature, and humidity, while a DC water pump, controlled via a relay module, ensures precise irrigation. The Blynk app enables remote monitoring, pump control, and alerts for critical thresholds. Powered by a solar panel and battery, the system is energy-efficient and ideal for remote areas. Programmed using Arduino IDE, it minimizes water waste and manual effort, offering a sustainable and cost-effective solution.

Keywords: Soil Moisture Sensor, Node MCU, Solar Panel, Blynk IOT

1. INTRODUCTION

Agriculture is a key contributor to global food supplies, and effective irrigation is critical to the maintenance of sustainable agriculture. Conventional methods of irrigation, however, tend to result in wasteful consumption of water, high costs, and wastage of energy. With escalating issues regarding water scarcity as well as energy use, there is a pressing need for innovative methods to optimize irrigation. To meet these challenges, Smart Solar Power Irrigation Systems connected to the Internet of Things (IoT) have come as a solution in the offing (1,2).

A solar-powered irrigation system utilizes renewable energy to drive water pumps, minimizing reliance on grid electricity and fossil fuels. This change aligns with global sustainable development goals by encouraging the utilization of clean energy sources and minimizing greenhouse gas emissions (3,4). Using solar energy, farmers can drastically reduce operation expenses while having an efficient and green irrigation system. The technology is especially useful in distant and off-grid farming areas where conventional electricity access is limited (5,6).

The use of IoT-based sensors is a game-changer in current irrigation systems. IoT-based sensors facilitate real-time monitoring of important parameters like soil moisture, temperature, humidity, and water levels. Through this data analysis, automated controllers can maximize irrigation schedules so that crops get the amount of water they need at the appropriate time. This accuracy minimizes water wastage and maximizes crop health, thereby enhancing agricultural productivity (7,8). Research has indicated that smart irrigation systems can minimize water usage by as much as 50% while maximizing crop yield and efficiency (9).

A smart solar-powered irrigation system has a few crucial components that collaborate to improve efficiency and sustainability:These sensors measure soil moisture, temperature, and humidity and offer real-time data for accurate irrigation control (2,10).These modules facilitate smooth data transmission between the sensors, controllers, and cloud-based platforms to ensure proper monitoring and decision-making.These devices process sensor data and control water pumps accordingly, optimizing irrigation schedules and minimizing waste.Platforms: Advanced cloud computing tools analyze collected data, providing farmers with insights into irrigation patterns and efficiency.These panels harness renewable solar energy, ensuring a sustainable power source for irrigation systems.These algorithms forecast irrigation needs as a function of weather trends, soil type, and past records and further enhance efficiency (11,12).A number of technological innovations have led to the fast evolution of IoT-based smart irrigation systems.

Another innovation is the use of AI-driven decision-making models that optimize irrigation efficiency. These models rely on real-time and past data to forecast irrigation requirements, enabling farmers to make data-driven decisions regarding water allocation. Another innovative solution is drone-based irrigation monitoring. Drones with sophisticated imaging capabilities can evaluate crop health, identify regions with poor irrigation, and offer actionable recommendations for improved water management (9).

Smart solar-powered irrigation systems have various advantages for farmers and the environment. The systems provide accurate irrigation control, optimizing water distribution with minimal wastage. Farmers also get to save on operational costs through reduced water and electricity costs. Additionally, the systems are environmentally friendly, as they lower carbon footprints and encourage sustainable water use. As technology advances, the prospects for smart irrigation are bright. AI-driven automation, remote sensing, and data analytic are likely to further improve irrigation management to make farming even more resource-saving. The incorporation of block-chain technology into smart irrigation systems could also increase data security, guaranteeing transparency in water use and resource distribution.

1.1 RELEVANCE

The smart irrigation system project is greatly pertinent in solving the world problems of water saving and sustainable farming. Through the integration of IoT technology and renewable energy, the system offers a unique solution to the optimal use of water in agriculture. With ESP32 and sensors used, the monitoring and control are accurate, while solar power maximizes its energy efficiency and environment friendliness. This project is in accordance with the emerging demand for smart, sustainable agricultural practices, which lead to greater productivity and environmental protection.

1.2 OBJECTIVE

- The primary aim of suggested project is water utilization in well way thus water can be conserved
- The motor pump automatic ON/OFF by sensor lowers the human presence
- The water supply status can be tracked by remote location through IOT technology.
- To obtain the correct environmental conditions. 1.3 Problem Statement Agriculture is the backbone of Indian Economy. But for agriculture, water usage is greater than rainfall annually. Farm yield needs to be enhanced to satisfy the fast-growing demand of food for population growth worldwide. An automated irrigation system is required to maximize water usage for agricultural corps. The method can be utilized to apply correct quantity of water. With the creation of sensor network, effective monitoring of water control in agriculture sector can be done. Sophisticated equipment and innovation can be utilized to enhance yield of farm. The node's micro-controller is responsible for controlling relay switching unit and watering subsystem accordingly.

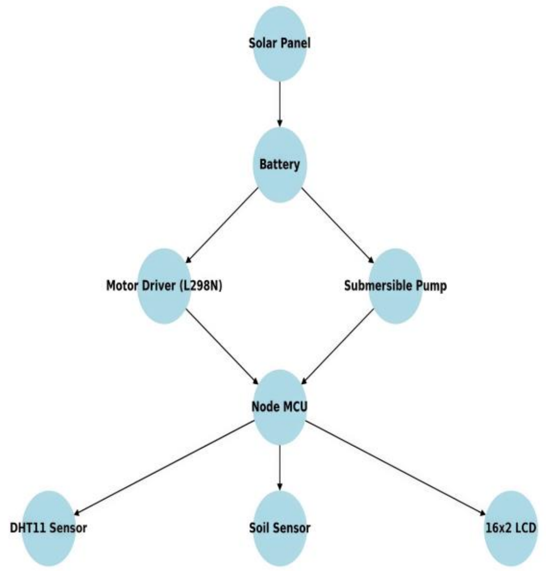

Fig: Block Diagram of Smart Irrigation System

2. COMPONENTS:

2.1 Node MCU

- ➢ The micro-controller that acts as the "brain" of the system, processing sensor data and controlling the pump.
- ➢ It also connects to the Blynk app via Wi-Fi.

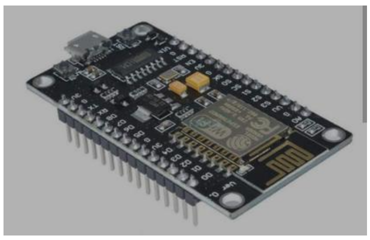

Fig: Node MCU

2.2 DHT11 TEMPERATURE AND HUMIDITY SENSOR

- ➢ Measures temperature and humidity of the surrounding air.

- This DHT11 temperature and humidity sensor has a calibrated digital signal output with the temperature and humidity sensing capability. It is also equipped with a high-performance 8-bit micro-controller. Its technology provides the high reliability and good long-term stability.

Fig: DHT11 Module

2.3 SOIL MOISTURE SENSOR

Soil moisture sensors quantify volumetric water content in soil. Because direct gravimeter estimation of free-soil moisture involves extraction, drying, and weighing a sample, soil moisture sensors quantify the volumetric water content by using some other characteristic of the soil, i.e., electrical resistance, dielectric constant, or neutron scattering, as indicator of the water content.

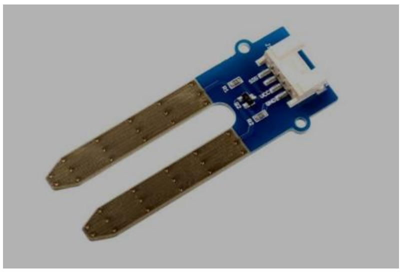

Fig: Soil Moisture Sensor

2.4. MOTOR PUMP

- Motor Pump is a rotary electrical machine that converts electric energy in the form of direct current into mechanical energy. The most frequent kinds depend upon the forces created by magnetic fields.
- The speed of a DC Pump can be varied over a wide range through either a variable supply voltage or by altering the intensity of current in its field winding's winding.

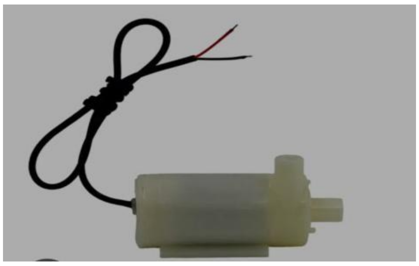

Fig: Motor Pump

2.5. L298N MOTOR DRIVE

The L298N motor driver controls the speed and direction of rotation of a DC electric motor. It employs a L298N PWM system, which is capable of controlling voltage with square wave pulses. The broader the pulses, the more rapidly the motor will spin.

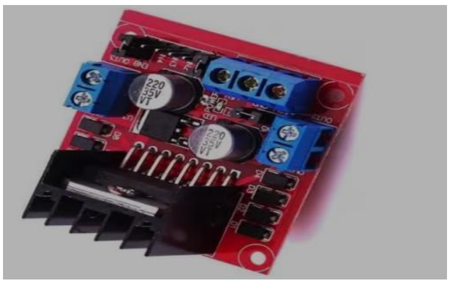

Fig: L298N Motor Driver

2.6. SOLAR PANEL

Solar panels or photovoltaic (PV) modules are instruments that transform sunlight into electricity based on the photovoltaic effect, a phenomenon where light energy is absorbed by a material (typically silicon) and produces electricity.

Fig: Solar Panel

2.7. LCD DISPLAY

A liquid-crystal display (LCD) is a flat panel display. electronic visual display, or video display that exploits the light modulating characteristics of liquid crystals. Liquid crystals are not light emitters. LCDs can be made available to show arbitrary images, like preset words, digits, and 7-segment displays as in a digital clock.

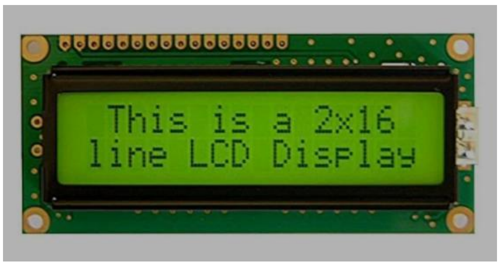

Fig: LCD Display

2.8. LIPO BATTERY

Battery, in electricity and electrochemistry, any of a class of devices that convert chemical energy directly into electrical energy.

Fig: LIPO Battery

3. EXPLANATION

solar irrigation system functions with taking into account the given parts and code snippets.

10W Solar Panel, This produces electricity from sunlight. Stores solar energy in 4 cell battery for utilization when sunlight is lacking. L298N Motor Driver Manages the Mini Submersible Pump's functionality (switching it ON/OFF).

Mini Submersible Pump utilized for water irrigation. Moisture Sensor is utilized to Measures soil moisture content. DHT11 Humidity Sensor which Measures ambient temperature and humidity. Node MCU (ESP8266) micro-controller serves as the "brain" of the system, interpreting sensor readings and operating the pump. It also communicates with the Blynk app through Wi-Fi.Jumper Wires Used to connect the components.Line LCD Display to display the sensor reading and system status.Blynk App is mobile application for remote monitoring and control.System Workflow the solar panel recharges the batteries.The NodeMCU and other devices get power from the batteries.Sensor Data Acquisition the Moisture Sensor constantly checks the soil moisture.The DHT11 sensor checks the temperature and humidity.The NodeMCU reads the sensor reading.Data Processing the NodeMCU processes the sensor reading.It can be programmed to check if the soil moisture is less than a certain value Manual Control through Blynk.The Blynk app offers a user interface with buttons to control the pump. The Blynk_app_command(command) function processes these commands

* "ON": Switches the pump ON, sets pump_state to "ON", and disables auto mode.

* "OFF": Switches the pump OFF, sets pump_state to "OFF", and disables auto mode.

Pump Control and Node MCU sends signals to the L298N motor driver to switch the pump ON or OFF.

Then Data Display on display. The NodeMCU transfers the sensor data and pump state to the line LCD display for local monitoring. The NodeMCU also transfers the sensor data and pump state to the Blynk app for remote monitoring. Blynk app shows the sensor data and pump status. Users can manually control the pump using the buttons of the app.

4. CONCLUSION

The Solar-Powered Automatic Irrigation System is an efficient and sustainable agricultural solution. With solar energy, it reduces the dependency on traditional power sources, making irrigation less expensive and environmentally friendly. The integration of soil moisture sensors guarantees precise watering, ensuring that there is no over-irrigation and minimizing water loss. The smart automation system decreases manual labor and optimizes irrigation cycles, enhancing agricultural productivity. The system has proved to be reliable in different weather conditions, showcasing its durability and effectiveness. With low maintenance, it provides a long-term, cost-saving solution for farmers. Moreover, by encouraging the use of renewable energy, it minimizes carbon footprint and encourages sustainable farming.

5. RESULT

Solar-Powered Automatic Irrigation System is a cost-effective, environmentally friendly way of agricultural irrigation. The use of solar energy minimizes reliance on the traditional electricity grid while providing ongoing irrigation. Optimizing water application is done using soil moisture sensors to avoid excessive watering and waste. Automation within the system cuts out the manual factor, boosting accuracy and effectiveness. It can work effectively across diverse environmental factors, making it an affordable, long-term solution. Having low maintenance needs and long-term economic advantage, this system promotes resource-conserving agriculture. Its effectiveness in practice presents it with a strong case for wholesale uptake, which will lead to a more sustainable and productive farming industry.

Fig: Experimental setup of smart irrigation system

6. FUTURE SCOPE

The future scope of this project is vast, with potential advancements in technology and scalability. Integrating Artificial Intelligence (AI) and Machine Learning (ML) can further optimize irrigation schedules by analyzing historical data and weather forecasts, enhancing water efficiency. The use of drones equipped with multispectral imaging can provide real-time crop health monitoring, enabling precise irrigation adjustments. Expanding the system to include blockchain technology can ensure transparent and secure data sharing among stakeholders, improving resource management. Additionally, incorporating more renewable energy sources, such as wind or hybrid systems, can enhance reliability in diverse climatic conditions. The system can also be scaled for larger agricultural fields or adapted for urban farming, promoting sustainable practices globally. Collaboration with government initiatives can facilitate widespread adoption, addressing food security and water conservation challenges. Future research could focus on low-cost, modular designs to make the technology accessible to small-scale farmers, furthering its impact on sustainable agriculture.

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