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Solar-Powered Smart Irrigation System with Cloud Integration

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Abstract: Every engineering and non-engineering organization, be it a start-up organization or a multinational company, is dealing with IoT and automation. Today, all things are associated with the Internet, and all the latest products come with Internet connectivity as a standard instead of an optional feature. This system can be used at home, in the garden, or on a remote farm. It is designed to control and monitor the irrigation where the operator or owner cannot be on the farm. This work consists of different parts. The photovoltaic panel will initially transform the power. The power analyzer continuously tracks the power transferred and reports its findings to the Arduino board. Second, the solar tracking system incorporates light-dependent resistors as the controller's input to determine the direction of the greatest amount of sunlight, and the motor's output will mechanically rotate the solar cell in that direction. Thirdly, the irrigation system comprises the sensor, which measures soil moisture and transmits the reading to the controller; the water pump, which responds to Arduino commands by turning on or off; and last, the user-to-system communication channel, which is the IOT cloud on the Wi-Fi network. The mobile application has three gauges that display the voltage cell and power cell. Also, for user convenience and comfort, a dedicated gauge will display the soil moisture level. If the automatic option is used, the appropriate level of soil moisture can be specified using the soil moisture slider on the application.

Keywords: *Solar Energy, photovoltaic, Arduino, soil moisture, Relay*.

1. Introduction

A Blynk IoT smart plant monitoring system is a technology-based solution that enables the monitoring of plant growth and health using Internet of Things (IoT) technology [1]. This system allows you to keep track of plant growth data such as soil moisture, temperature, humidity, and light levels in real-time, as well as remotely control the environment to ensure optimal plant growth conditions [2]. A microprocessor, sensors, and actuators are often used to collect data and alter the environment based on the needs of the plant. The captured data is transferred to the cloud, where the user can access it via the Blynk app [3] [4]. This technology offers numerous advantages, including the reduction of human work and the ability to cultivate plants more efficiently. By monitoring plant growth remotely, growers can quickly identify any issues and take action to any issues and take action to prevent crop loss, resulting in

In today's digital environment, we require that everything around us be automated to minimize human effort. Electronic circuits that simplify and ease modern life are becoming more prevalent. The two major issues that everyone is currently facing are the energy crisis and the water catastrophe. So, it is important to conserve both water and energy [6]. Making a solar-powered prototype to autonomously irrigate the field is the goal of this. Consider how useful it will be when your field is being irrigated automatically and cheaply while you are occupied with your next chore. You don't have to worry about under or over-irrigating, wasting water or money on pricey electricity, or your hectic schedule. This is what automatic irrigation is all about, and there are countless ways to use it in real life [7]. The name of the system, "AUTOMATIC IRRIGATION SYSTEM USING SOLAR ENERGY," indicates that it automatically turns off when soil moisture levels rise over the reference value and irrigates the field when they fall below it [8].

IoT-based intelligent farming systems are employed to achieve beneficial results [9] and overcome problems in agriculture [10]. Global and regional agricultural monitoring systems aim to provide up-to-date information on food production [11]. In IoT-based smart agriculture [12], a system is set up to monitor fields using sensors [13] such as light, humidity, temperature, soil moisture, etc. In addition to automatically irrigating water based on soil moisture levels, it also sends data to ThingSpeak servers to track soil conditions [14]. Collect sensor data using wireless communication to eliminate loose signal lines and cables in the field. This project is a culmination of educational experiences that integrate the classroom with real-world problems. The planned use of energy in irrigation requires large amounts of fossil energy for both pumping and supplying water to crops [15]. Overall, the amount of energy

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higher yields and better plant health [2] [5].

expended in the production of irrigated crops is considerably higher than that of rain-fed crops [2].

2. Methodology

With agriculture accounting for 18% of India's Gross Domestic Product (GDP) [15] and employing half of the country's workforce [16], farming is one of the most important sectors [17] of the Indian economy. India is a productive Asian nation, according to the agriculture sector's productivity [18]. So, the Internet of Things is crucial in achieving that level of agricultural output. Hence, a revolutionary Solar-Powered IoT Irrigation System could be part of smart agriculture [19]. A farm monitoring system is a combination of hardware and software add-ons. The hardware part contains the embedded system and the software program is the Arduino IDE. The collected information can be viewed in the Arduino IDE. An ESP-01 module is connected to the Arduino to facilitate a notification service that informs farmers of the object's climatic conditions every 10 seconds.

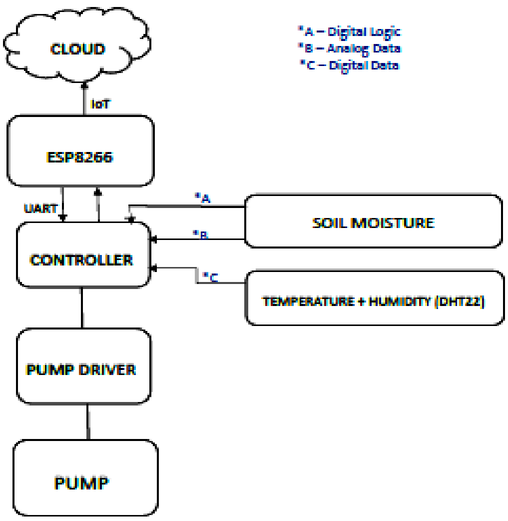

Fig. 1. Block diagram of a system

Using smart sensors to create smart farms and these sensors will ultimately lead to precision agriculture is one technique to deal with agricultural problems or their rise in complexity and amount of produce [20]. The module that measures humidity, temperature, soil moisture, rain frequency, and light intensity was created by the authors. It tells the farmer which seed is ideal for their field through a graphical user interface. Their design's architecture incorporates a Wi-Fi module and sensors for temperature, wetness, and humidity. A software package comprises an IoT platform that involves the installation of an irrigation profile based on the season, the day of the week, or both. The Main Module notification is sent by the software, which instructs the controllers to turn on and off. Physical factors are sensed by sensors, which then translate analog input into digital output. The most important component of this system, is the Wi-Fi modem, which transfers data to the cloud via an IoT gateway. The device's cloud includes a database to store the data acquired from the IoT gateway.

The following are the execution steps for the proposed system:

a. Hardware Selection: Select the necessary hardware components, such as a microcontroller, actuators and sensors.

b. Install the hardware: Connect the components and test their functionality.

c. Microcontroller programming: Create the code that will control the sensors and actuators as well as gather and transmit data. The Arduino IDE, PlatformIO, or another programming tool can be used.

d. Blynk account: Create a Blynk account and start a new project. To use your microcontroller, we will need to obtain an authentication token.

e. Install the Blynk app: Create the user interface for the Blynk app, including buttons, gauges, and data visualization graphs.

f. Link the microcontroller: Connect our microcontroller to the Blynk app using the Blynk library. We'll need to enter our authentication token and customize our microcontroller's settings.

g. Test the system: Run the system and make sure everything is working correctly. Monitor the data and ensure that it is being transmitted to the Blynkapp.

h. Deploy and maintain: Once the system is fully tested and functional, deploy it in the desired location and maintain it as needed. Ensure that the hardware and software are updated regularly to ensure optimal performance.

3. Implementation

IoT ushers in a new era that will fundamentally alter industrial and agricultural sectors and move them towards greater efficiency [21]. Many countries, like India, rely heavily on agriculture as a source of income [22]. As a result, there is a persistent urge to enter the Internet of Things universe. They created a model of a smart farming system to boost plant productivity. Their system focuses on three key components: machines, microcontrollers, and sensors. The "Internet of Things" is a network of connected computing devices, mechanical devices, and digital objects assigned unique identifiers (UIDs) [22]. In addition, IoT offers the ability for information to flow through a system without the need for person-to-person or person-to-person conversation. It is an ecosystem of interconnected smart devices that use embedded systems such as processors, sensors and hardware to collect, transmit and act on data collected from their environment. By linking to an IoT gateway, where serial data is transmitted to the cloud for analysis or evaluated locally, IoT-enabled devices link the acquired data.

3.1 ESP8266: It is a compact and versatile microcontroller module known for its Wi-Fi capabilities, ideal for IoT applications. It offers processing power, memory, and communication interfaces for seamless data exchange via Wi-Fi networks. With affordability and simplicity, it's a popular choice for projects from home automation to sensor networks, enabling connectivity in diverse devices.

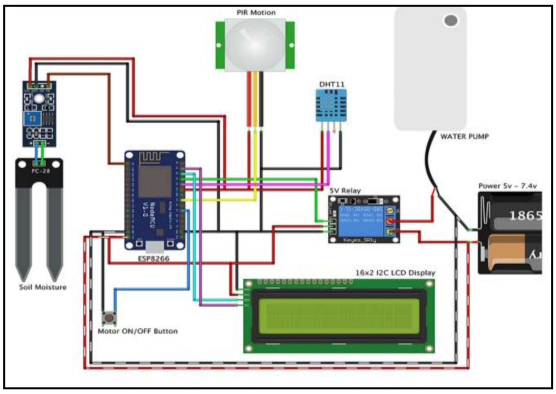

Fig. 2. Circuit diagram of the actual system

3.2 Functioning of System

In the circuit, 9V power comes from the adapter and feeds two channels (initially the 7805 regulator and the 1117 regulator). The 7805 regulator supplies 5V to the DHT22 sensor, soil moisture sensor, Arduino, and pump. Simultaneously, the 3.3V output from the 1117 regulator is directed to the ESP8266 device. Digital and analog data are transmitted to the controller from soil moisture sensors and temperature and moisture sensors. The controller processes this data, resulting in three primary outputs. Temperature and humidity readings are displayed on the LCD device and simultaneously transmitted to the ESP8266 through a UART script for cloud integration. Pump control is managed by the controller using NPN transistors.

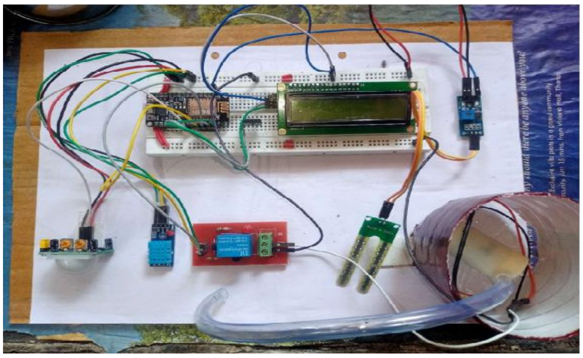

Fig. 3. Actual module

Figure 3 shows the actual implementation module of the system. The implementation of the proposed system uses a separately designed and manufactured 2 hp water pump and various modules that are finally assembled to implement the proposed system. Solar energy is harnessed using PVL-68 solar panels, producing 53W at nominal cell operating temperature. 24V amorphous silicon solar cell.

3.3 Selected solar panel specifications:

- Array Capacity - 240Wp
- Irradiation - 580 W/m2
- Open circuit voltage - 18.1V
- Short circuit current - 3.98°

4. Results

Stress tests have been run on solar panels and the maximum and minimum values are tabulated below.

Table 1. Test Characteristics of Solar Panel

Sr. No	Voltage (in Volts)	Current (in Ampere)	Functionality and Application
1	5.2	1.45	300
2	17.5	2.95	710

Table 1 displays the voltage and current generated by the solar panel system. These measurements are crucial for comprehending the system's performance across diverse conditions, including fluctuations in sunlight intensity and voltage levels. They offer valuable insights into the system's responsiveness to alterations in sunlight and electrical attributes. Notably, an elevation in voltage leads to a reduction in current, while an upsurge in voltage corresponds to an increase in irradiance, reflecting the heightened intensity of sunlight reaching the solar panel.

A. Web Dashboard

The outcomes are viewed on a web dashboard, a comprehensive platform meticulously crafted to offer real-time visualizations and data insights. This user-friendly interface provides easy access and interpretation of solar panel data.

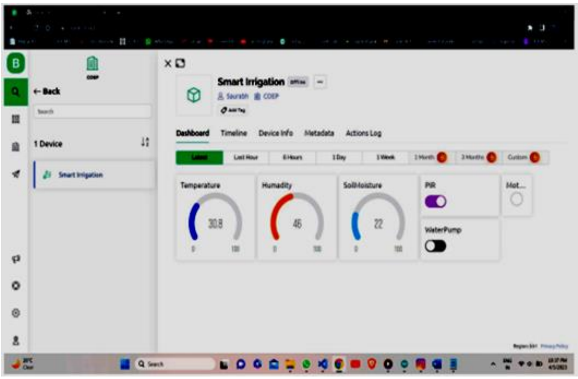

Fig. 4. Web Dashboard

Through interactive data displays, the system's performance is showcased, encompassing temperature, humidity, and soil moisture results. The visual representation of data is depicted in the figure below.

B. Smartphone Dashboard

The Smartphone Dashboard for the Solar-Powered Smart Irrigation System presents a user-friendly interface accessible through smartphones. Similar to the web dashboard, it facilitates real-time monitoring of vital environmental parameters such as temperature, humidity, and soil moisture. Through easily understandable graphs depicted in the Figure below, users can swiftly access current readings. Cloud integration further amplifies accessibility and enables remote control functionalities.

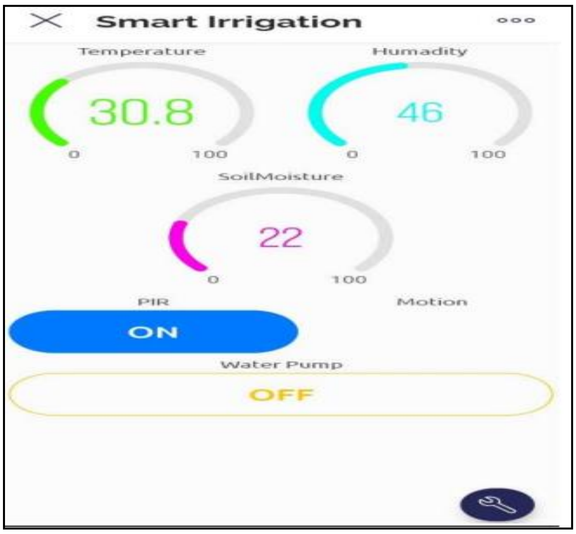

Fig. 9. Smartphone Dashboard

This dashboard empowers users to make informed and efficient irrigation decisions while on the move, contributing to the promotion of sustainable agricultural practices.

C. Benefits of the proposed system:

- **Real-time monitoring:** The system provides real-time data on the environmental conditions that affect plant growth, enabling users to make timely decisions to address any issues.
- **Remote control:** The system enables users to remotely control the environmental conditions of their plants, ensuring that they are within the desired range.
- **Increased productivity:** The system can increase the productivity of plants by ensuring that they receive the optimal environmental conditions for growth
- **Reduced costs:** The system can reduce costs associated with manual monitoring and control of plant growth, as well as reduce waste by ensuring that plants receive the optimal environmental conditions for growth.

5. Conclusion

The IoT-based Smart Plant Monitoring System is a cutting-edge use of Internet of Things technology that provides customers with numerous benefits such as real-time monitoring, remote control, enhanced productivity, and cost savings. The system consists of hardware devices, software applications, and networking protocols that collaborate to provide remote monitoring and control of environmental factors that affect plant development. The Blynk IoT Smart Plant Monitoring System helps users to make informed decisions about their plant's health and growth by giving real-time data and alarms, assuring optimal growing circumstances. Overall, the Blynk IoT Smart Plant Monitoring System exemplifies how Internet of Things technology may be used to improve numerous aspects of our lives, such as plant development and agriculture. The system has the potential to revolutionize the way we grow plants and help us meet the growing demand for food sustainably.

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