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Drip Irrigation System Integration with IOT and Renewable Energy for Sustainable Agriculture

Prof .Gokilavani M
Department of computer science and engineering.
Nehru institute of engineering and technology
Coimbatore

Akash S
Department of computer science and engineering.
Nehru institute of engineering and technology
Coimbatore

Sriganth M
Department of computer science and engineering.
Nehru institute of engineering and technology
Coimbatore

H. Hassan Riyas
Department of computer science and engineering
Nehru institute of engineering and technology
Coimbatore

Kishore B
Department of computer science and engineering.
Nehru institute of engineering and technology
Coimbatore

***Abstract*—This project explores the integration of drip irrigation with Internet of Things (IoT) technology and renewable energy sources to enhance agricultural efficiency and sustainability. The proposed system aims to optimize water usage through real-time monitoring and control of irrigation processes. Utilizing IoT sensors, data on soil moisture levels, weather conditions, requirements are collected, enabling intelligent decision-making for precise irrigation management. Additionally, renewable energy sources such as solar power are incorporated to provide an eco-friendly and cost-effective energy solution for powering the IoT devices and irrigation system. The synergistic combination of drip irrigation, IoT, and renewable energy contributes to resource conservation, improved crop yield, and overall sustainable agricultural practice.**

***Keywords*—Drip irrigation, Node MCU, IOT Microcontroller, moisture sensor, Dht-11, solar power**

OBJECTIVES:

To meet the rising global food demand amid population growth and shifting consumption habits, efficient water management in agriculture is paramount. Traditional irrigation methods often result in wasteful water usage and resource inefficiencies. Addressing these challenges, a solar-powered smart irrigation system employing IoT technology offers a solution to optimize water utilization, cut operational expenses, and foster environmental sustainability.

INTRODUCTION:

Over the years, several development and innovation have come across to further minimize the rapid depleting of natural resources in the environment. Basic necessities such as food and water have an integral part of everyday lives on Earth. Water plays a significant role in the environment. Globally, 70% of water come from natural resources such as groundwater systems, lakes and rivers to support crop irrigations and feeding of livestock. With the irrigation systems, it is important to maximize plant productivity, efficient energy consumption and reduce water wastage. Several approaches have been done by the researchers on how to improve the irrigation systems. With the global energy crisis, initiative for moving towards application of renewable resources carried out as possible solution. Investing on zero-carbon emission and using energy efficient products Energy

Efficiency and Cost-Effectiveness:
GOAL: Create an irrigation system that minimizes energy consumption and operational costs.
APPROACH: Utilize solar panels to harness renewable energy. Eliminate reliance on grid electricity Optimize water usage to reduce overall expenses

Integration of Sensor Parameters:
Goal: Collect relevant data for efficient irrigation management. Sensor Parameters: Soil Moisture Sensors: Measure soil moisture content at different depths. Provide real-time information on soil hydration levels. Enable precise irrigation scheduling. Temperature and Humidity Sensors: Monitor environmental conditions. Temperature affects plant

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growth, while humidity impacts soil evaporation. Data from these sensors guide irrigation decisions.

IoT-Based Monitoring and Tracking:
Goal: Enable remote management and real-time monitoring. IoT Technology: Communication Module (GSM or Wi-Fi): Establishes connectivity with the cloud or a central server. Send data and alerts remotely. Allows adjustments based on real-time information. Microcontroller (e.g., Arduino Uno) Collects data from sensors. Executes control logic. Communicates with other components. Solar-Powered Pump Activation: When irrigation is needed, the system activates the solar-powered pump. Water flows to the irrigation system. Energy Efficiency: Solar panels recharge batteries during the day. Stored energy powers the system at night. Minimizes reliance on non-renewable energy sources

Benefits and Sustainability:
Water Conservation: Precise irrigation reduces water wastage. Contributes to sustainable water management. Cost-Effective: Solar energy eliminates electricity bills. Long-term savings for farmers. Crop Health: Real-time monitoring ensures optimal conditions. Improves crop yield and quality. Remote Management: Farmers can control the system remotely. Receive alerts on their mobile devices. Environmental Impact: Harnessing solar power promotes eco-friendly practices. Efficient water use supports sustainable agriculture

EXISTING SYSTEM:

A conventional electric pump system for irrigation typically consists of an electric pump, a power source (such as grid electricity or a diesel generator), pipes, valves, and sprinklers or drip emitters. When activated, the electric pump draws water from a water source, such as a well, river, or reservoir, and pressurizes it for distribution to the fields. The system is controlled manually or through basic timers to determine when and how long the pump operates. Water is then delivered through the network of pipes and valves to the fields where it is distributed to crops through sprinklers or drip emitters. In this traditional setup, the pump runs based on a predetermined schedule rather than responding to real-time conditions in the field. This can lead to inefficient water usage, as the system may operate even when soil moisture levels are sufficient or when weather conditions do not necessitate irrigation. The reliance on grid electricity or fossil fuels for power also adds to operational costs and carbon emissions. Furthermore, without real-time monitoring, issues such as leaks or malfunctions in the system may go undetected, leading to water waste or uneven distribution. Overall, while conventional electric pump systems have been widely used for irrigation due to their simplicity and effectiveness, they often lack the precision and efficiency offered by modern technologies. The advent of IoT technology and renewable energy sources presents an opportunity to enhance these systems by enabling real-time monitoring and control, optimizing water usage, reducing operational costs, and promoting sustainability in agricultural practices.

PROPOSED TECHNIQUE:

Solar Powered Drip Irrigation

Expected Advantages:
This solar-powered smart irrigation system offers a sustainable and cost-effective solution for farmers. By harnessing renewable solar energy, the system minimizes its environmental impact while ensuring efficient water use for optimal crop growth. The elimination of electricity bills and fuel costs translates to significant long-term savings, boosting farm profitability. Furthermore, the system operates independently of the grid, providing energy security even in remote locations. The low-maintenance solar panels ensure reliable operation with minimal upkeep. This adaptable solution seamlessly integrates with diverse environments, from arid regions to lush landscapes. Additionally, the system scales effortlessly to accommodate small plots or vast fields, promoting sustainable crop production on any scale.

METHODOLOGY:

The developmental concept of solar powered smart irrigation system is to automate the irrigation process in an agricultural area. This is to minimize the carbon footprint in which the project aims to provide an energy efficient and plant productivity process. The "Solar Powered Smart Irrigation System" is a clean energy device that generates electricity from photovoltaic cells through solar technology. A back-up battery was also installed for excessive power storage and serves as a power back up in the event of minimal solar power

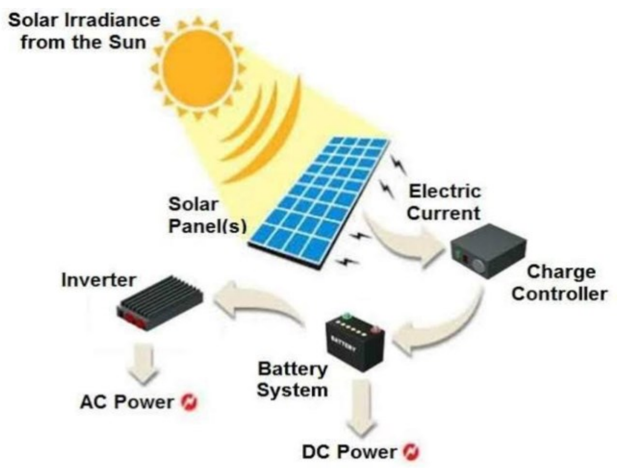

Figure 1 How Solar Energy Works

The aim of this project is to improve the overall efficiency and sustainability that utilizes clean-energy and technological innovation. With the revamp of IoT on agricultural business, it will create a strategic and well-managed irrigation practices. This may result to good environmental outcomes and overcome perceived climate intensification issues.

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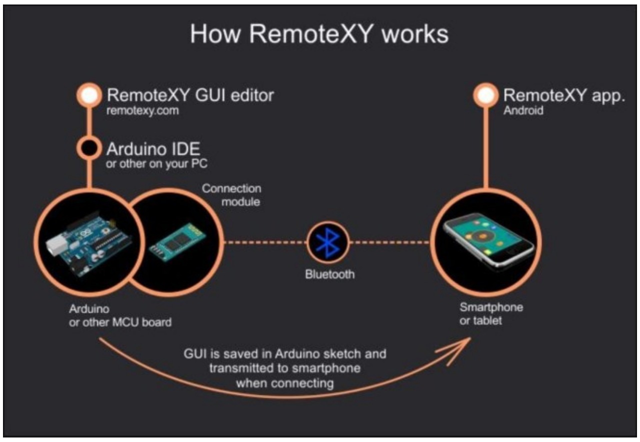

Figure 2: How Remote XY Works

Figure 3 represents the block diagram of the essential components of the solar powered smart irrigation system

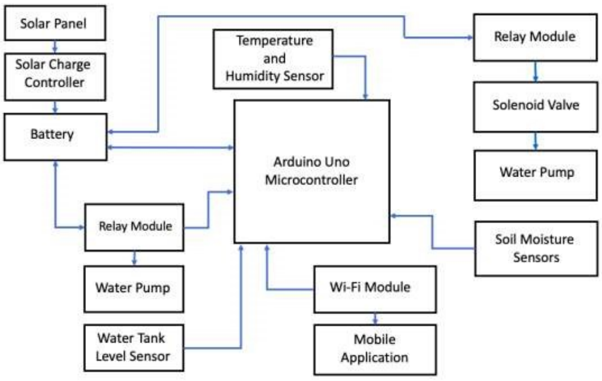

Figure 3: Block Diagram of the Smart Irrigation System

Based on Figure 4, it represents the flow chart of how the irrigation system works. It starts with the mobile app initialization of the user and powering on the main controller of the system. Various sensors will acquire data from the temperature and humidity sensor, moisture sensor and water tank level sensor. For the water pumps to work, set point values have been establish within threshold limits. The acquired data will be sent to the mobile application for the user to remotely monitor the system via the Wi-Fi module.

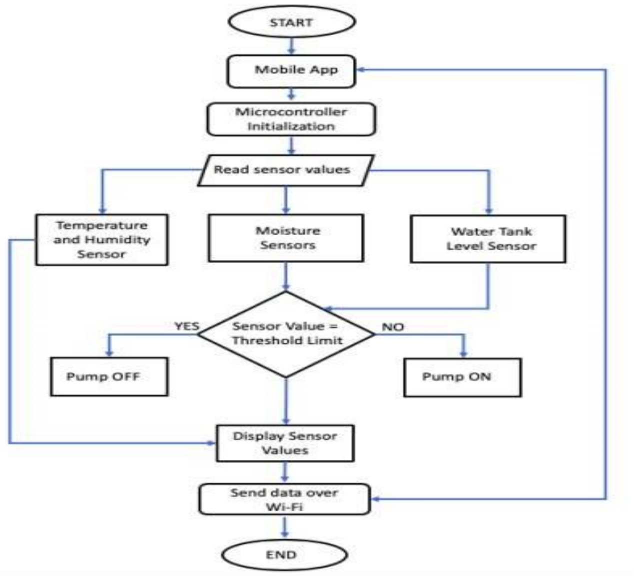

Figure 4: Flow Chart of the Irrigation System

COMPONENTS OF HARDWARE

1.Arduino Uno

Arduino Uno – the main controller of the unit that is an open source platform for any development environment. It is microcontroller board based on 8-bit ATmega328P microcontroller. It consists of 14 digital input/output pins, 6 analog input pins, USB connection, power jack and reset button. The system has also components that includes crystal oscillator, voltage regulator and serial communication. The Arduino Uno can be used to communicate in other devices using UART TTL (5V) on digital pin 0 (Rx) and digital pin (Tx). It can also communicate via USB drivers using ATmega16U2 firmware to be connected on the computer. The Arduino Uno can be programmed through an Arduino software using Wire library that can simply the use of I2C and SPI communication.

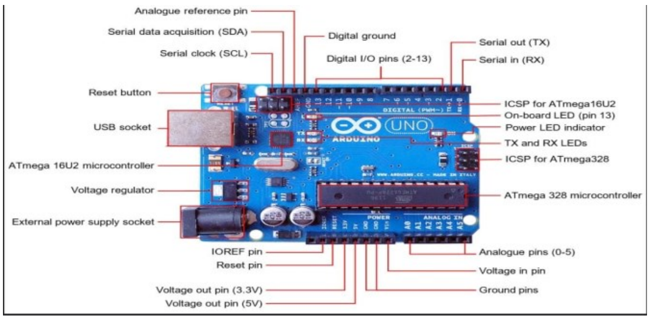

Figure 5: Arduino Uno Pinout Diagram

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Technical specs

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Figure 6: Arduino Uno Technical Specifications

2.Solar Panel

Photovoltaic arrays generate electricity from solar energy. The 12V solar panel is in accordance with IEC61215:1993 standards, using low iron tempered glass and EVA film with TPT back sheet to encapsulated cells.

Figure 10. Solar Panel

3.12V Battery

the main power supply of the system which is interconnected wit solar charge controller and solar panel. If electricity is not generated to the solar panel as lack of sunlight, the supply power to the system comes from the battery. The solar panel can also charge the battery in the event of excessive power supply.

Figure 7: 12V DC Battery

4.Soil Moisture Sensor

soil moisture sensor measures and detects the soil moisture level through capacitive sensing if the plants need water. It is a corrosion resistant material compared to other moisture sensors. It operates on 3.3V~5V with high sensitivity and accuracy.

Figure 8: Soil Moisture Sensor

5.Relay Module

the 5V 4-channel relay interface board able to control the water pump for the plants. the 5V 1-channel relay for the water tank. Both relays is controlled directly by microcontroller.

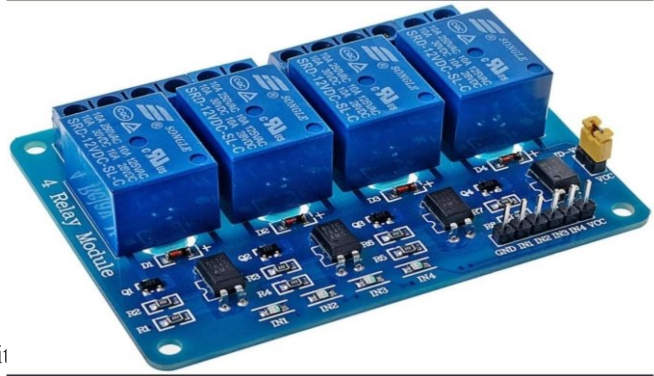

Figure 9: Relay Module

6.DHT11 Temperature

It is an 8-bit microcontroller to output the values of temperature and humidity. The sensor has NTC (Negative Temperature Coefficient) to measure from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%. The sensor module is

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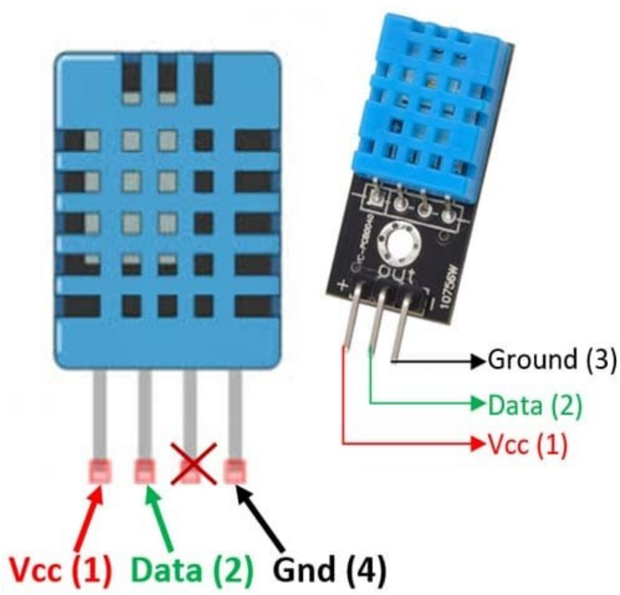

Figure 10: DHT11

7.ESP8266 Wi-Fi Module
this module is popular for its application on Internet of Things. The operating voltage for this module is 3.6V. It is a self-contained SOC that integrates with TCP/IP protocol that can communicate with the microcontroller to Wi-Fi network.

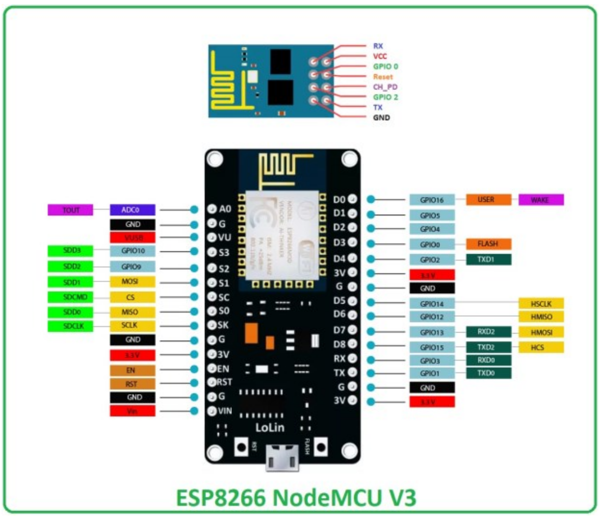

Figure 11: ESP8266 Module Pinout Diagram

8.Water Pump
the system consists of two pumps for the water storage tank for the watering of plants in which the water takes from the storage tank and output it through the valves

Figure 12: Water Pump

9.Serial LCD Display
serial LCD display is an LCD (liquid crystal display) that connects to a microcontroller or other device using a serial communication protocol. It simplifies wiring and control by handling the communication internally, requiring only one pin for control. These displays find applications in industrial control systems, medical equipment, automotive displays, and consumer electronics products.

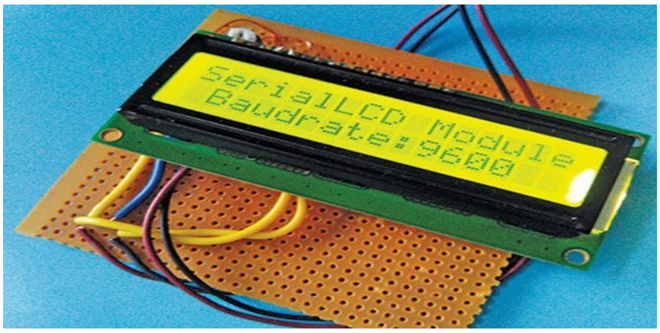

Figure 13: Serial LCD Display

10.Buzzer
A buzzer is a small electronic device that produces sound. In the realm of IoT (Internet of Things), buzzers are used to provide audible notifications or alerts from devices or systems. These alerts can be simple beeps or tones, or they can even play short melodies or pre-recorded messages.

Figure 14: Buzzer

SOFTWARE APPLICATION:

1.Arduino IDE Software

Used to program the system. It is an open-source platform that is easy to write programming language and upload to the microcontroller. It can on any software environment like Windows, Mac OS and Linux.

Figure 15: Arduino IDE Software

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2.Blynk

Blynk is a free app for smartphones and tablets that allows you to control hardware remotely using the Internet of Things (IoT). With Blynk, you can easily build a variety of interfaces for controlling electronics, reading sensor data, and visualizing data streams from sensors or other devices. Blynk provides a library of pre-built widgets for buttons, sliders, graphs, and more, allowing you to design your own app interface without coding.

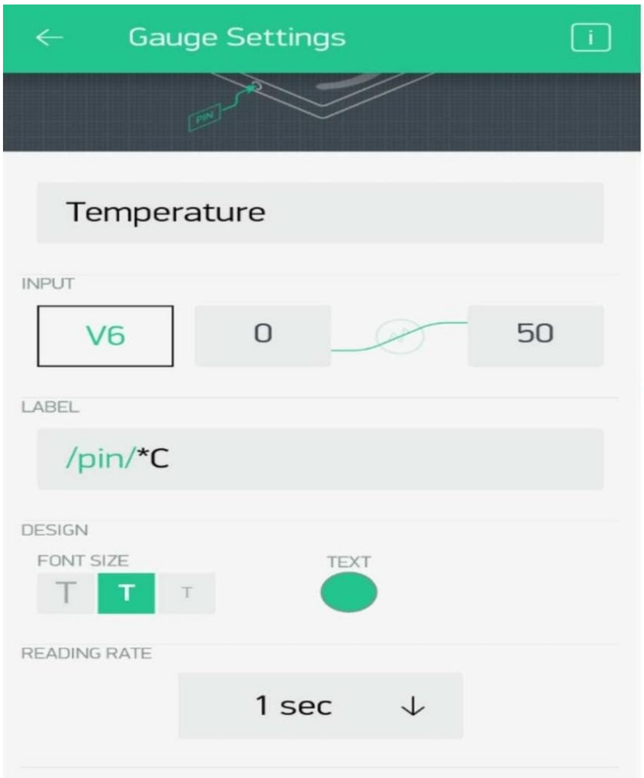

Figure 16: Blynk

CONCLUSION

The solar powered smart irrigation system using IoT demonstrates a collection of data using sensors for productivity and efficiency. The generates a clean energy by utilizing the solar generation technology which improves cost management and waste reduction for overall improved system performance. The system also allows monitoring the irrigation process without manual intervention hence achieving optimized results and more efficient use of water resources.

The system is set to deliver a more productive and sustainable irrigation method and beneficial to the environment.The system may be further modified in the emerging technology which stores the data to the cloud server for further analysis and immediate actions if necessary. Also, several sensors can be added to the system such as tracking the climate conditions with rainfall sensor and further improvement on the large-scale basis.

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