

Solar-Based Smart Irrigation System using IOT

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Abstract - The demand for water and energy farming systems is going up. This is why we need to develop ways to water our plants. The project called "Solar-Based Smart Irrigation System using IoT" is trying to make watering automatic. It uses energy and smart sensors to do this. The system is built around a computer called the ATmega328p microcontroller. This computer talks to sensors like the DHT11 sensor that measures temperature and humidity. There is also a soil moisture sensor that checks the soil condition. The LDR sensor measures how light there is and the ultrasonic sensor checks the water level. We use a panel to give power to the system. The solar panel gives 12V of power which is then changed to 5V so that the system can work well. This is good for farms that're far away from cities and do not have a lot of electricity.

All the information we get from the sensors is shown on a screen and sent to the internet using the ESP8266 Wi-Fi module. We can see all the information on the ThingSpeak website. When the soil is too dry the system automatically turns on the water pump to water the plants. This means people do not have to do it. It also helps to save water and grow crops. The solar energy and internet connection make the system good for the environment cheap and sustainable. This helps to make farming better and smarter. The Solar-Based Smart Irrigation System using IoT is a step forward, for modern farming.

Key Words: IOT, Solar, DHT, LDR, Wifi etc.

Key Words: LDR(Light Dependent Resistor), Solar, Tracking.

1. INTRODUCTION

Solar Agriculture plays a crucial role in the global economy, but traditional irrigation systems often result in water wastage, energy inefficiency, and reduced crop productivity. With the increasing demand for sustainable agricultural practices, modern technology can help improve irrigation efficiency and crop management. The Solar-Based Smart Irrigation System using IoT integrates renewable energy, sensor technology, and cloud-based monitoring to optimize water usage and enhance productivity.

The system uses a solar power supply to drive the irrigation setup, making it suitable for remote areas with limited grid access. Through IoT (Internet of Things) integration, real-time data such as temperature, humidity, soil moisture, and water levels are monitored and uploaded to ThingSpeak Cloud for analysis and remote control. Traditional irrigation systems rely on manual control, leading to inefficient water usage and unnecessary energy consumption. With the evolution of embedded systems and IoT, automation has transformed various sectors, including agriculture.

The ATmega328p microcontroller serves as the brain of the system, interfacing with multiple sensors such as DHT11 (temperature & humidity), soil moisture sensor, ultrasonic water level sensor (SR04), and LDR for light intensity. A solar panel provides renewable energy that is converted to 5V using a DC-to-DC converter, making the system self-sufficient.

2. MOTIVATION

The motivation for developing the Solar-Based Smart Irrigation System using IoT is to address these challenges by integrating renewable solar energy, sensor-based automation, and IoT-enabled remote monitoring. By using solar power, the system operates independently of the electrical grid, making it suitable for off-grid farming. Real-time monitoring of soil moisture, temperature, humidity, light intensity, and water levels ensures precise and efficient irrigation.

Additionally, IoT connectivity allows farmers to remotely track field conditions, make data-driven decisions, and improve crop management without constant physical supervision. This project aims to combine technology and sustainability, promoting water conservation, energy efficiency, labor reduction, and enhanced agricultural productivity.

3. BACKGROUND

Recent advancements in embedded systems, renewable energy, and Internet of Things (IoT) technologies have significantly contributed to the modernization of agriculture. Researchers worldwide

have explored various smart irrigation techniques that optimize water usage and enhance productivity while reducing dependency on human intervention. The following review summarizes existing works and technological contributions relevant to the Solar-Based Smart Irrigation System using IoT.

IoT in Smart Irrigation: IoT technology has enabled real-time monitoring and control in agricultural applications. According to Patel et al. (2021), IoT-based irrigation systems help farmers remotely monitor soil moisture, temperature, and humidity through cloud platforms like ThingSpeak and Blynk. The use of microcontrollers such as Arduino and NodeMCU allows seamless sensor integration and automated water pump control based on real-time soil data.

Solar-Powered Agricultural Systems: Energy scarcity in rural and remote regions has made solar energy a practical alternative for powering irrigation systems. Sharma and Verma (2020) demonstrated a solar-based water pumping system using photovoltaic (PV) panels that supply power to DC pumps for irrigation. Integrating solar power with IoT provides sustainable, continuous operation even during power outages, reducing dependence on the conventional grid.

Sensor-Based Irrigation Control: The implementation of sensors in irrigation has revolutionized agricultural automation. Studies by Kumar et al. (2019) utilized soil moisture and DHT11 sensors for real-time monitoring of environmental parameters. When soil moisture drops below a defined threshold, the microcontroller triggers a relay to start the water pump automatically.

Automated Irrigation Using Soil Moisture Sensors: Researchers introduced soil moisture-based control systems to automate the irrigation process. For instance, Patil and Kulkarni (2018) developed a system using an Arduino microcontroller and soil moisture sensor to control a water pump. The system automatically turned the pump ON/OFF depending on the soil's moisture content, helping to minimize water usage.

Cloud Integration and Data Analytics: Cloud-based platforms like ThingSpeak, Firebase, and AWS IoT have become essential for agricultural IoT applications. Reddy et al. (2022) emphasized that data visualization and analytics on cloud platforms help farmers make informed decisions regarding irrigation schedules, soil condition trends, and weather patterns. The ThingSpeak cloud, used in this project, enables real-time graphical data representation, making it easier to monitor and analyze environmental conditions from any location.

2. TECHNOLOGY

4. BLOCK DIAGRAM

Block diagram of the system is shown in Figure 1 In which we see ‘Solar Tracking Monitoring’ is automatic maintenance system. In this system there are several blocks namely Driver, Controller, Sensors, LCD.

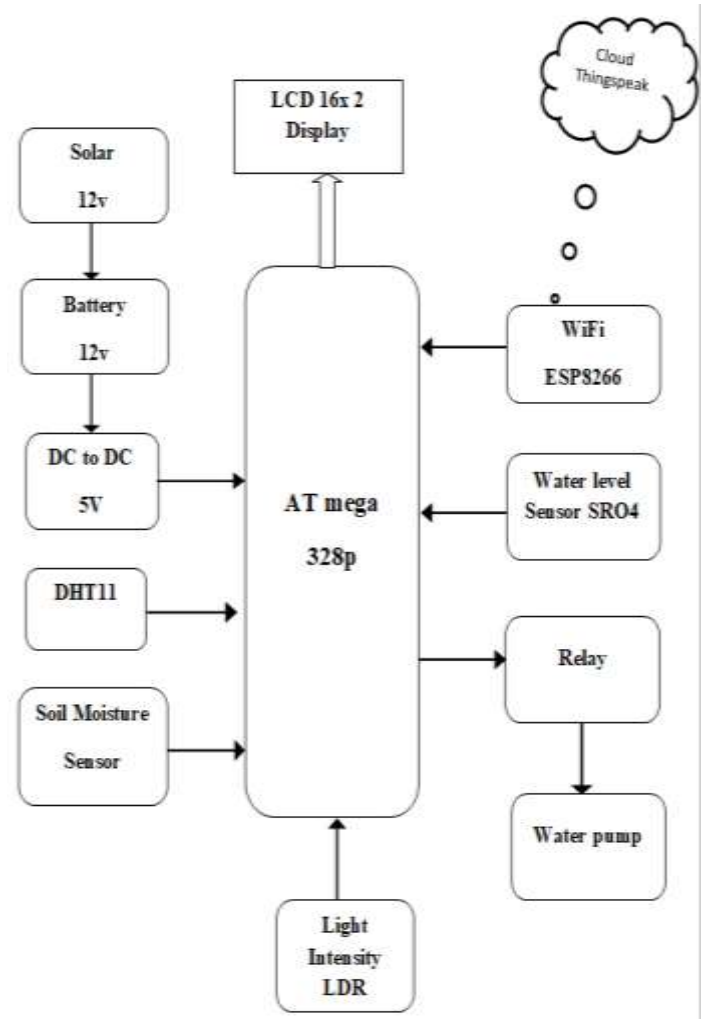


Figure 1: Block Diagram of The Solar power Soil, Monitoring & Irrigation

Below is the detail information about the system:

4.1 ATMEGA 328

The main advantage of using ATmega 328 is its high functionality with simplicity and familiarity. ATmega 328 connects the solar system and IoT (Internet of Things). ATmega 328 is a high Performance, Low Power AVR® 8-Bit Microcontroller

- Advanced microcontroller with RISC Architecture.
- Up to 20 MIPS Throughput at 20 MHz .
- 32K Bytes of In-System Self-Programmable Flash program memory
- Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
- Two 8-bit Timer/Counters
- One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture

4.2 LDR (Light Dependent Resistor):

A Light Dependent Resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. This called as photo conductors, photo conductive cells or simply photocells.

4.3 Motor Driver L293D

Motor driver is basically a current amplifier which takes a low-current signal and gives higher current signal through microcontroller which can control and drive a motor. The L293D is quad push-pull drivers capable of delivering output currents to 1A or 600mA per channel respectively. It has High Noise Immunity and back EMF protection.

4.4 LCD display

A simple 16*2 liquid crystal has been used to provide a graphical user interface.

4.5 Power Supply

Most are designed to convert high AC to DC voltage supply for electronic circuits and other electronic circuits and other devices. A power supply can cut down into a series of blocks each of can performs a particular function. Lm7805 regulator has been used provide 5v regulated and up to 1 ampere current for microcontroller and sensors.

4.6 ESP8266 Wi-Fi Module:

ESP8266 offers a complete and self-contained Wi-Fi networking solution, which allow it to either host the application or to offload all Wi-Fi networking functions. When it is the only application processor in the device, it is able to boot up directly from an external flash. It has integrated cache to improve the performance of the system in such applications, and to minimize the memory requirements. The ESP8266EX microcontroller integrates a 32-bit RISC processor, which achieves extra-low power consumption and reaches a maximum clock speed of 160 MHz.

4.7 LCD Display:

This display contains two internal byte wise resistors, One for the commands (RS=0) and second for character to be displayed (RS=1). It also contains a user programmed RAM area (the character RAM) that can be programmed to generate any desired character that can form using a dot matrix. To distinguish between these two data areas, the hex command byte 80H will be used to signify that display RAM address 00H is chosen. Port 1 is used to furnish the command or data byte, and ports 3.2 to 3.4 furnish register select and read/write levels. The display takes varying amounts of time to accomplish the functions. LCD bit 7 is monitored for logic high (Busy) to ensure the display is not overwritten.

4.8 Soil Moisture Sensor

Soil Moisture Sensor is a simple device that measures the volumetric content of water within the soil. It allows for monitoring soil moisture levels to determine if the soil needs watering, making it highly useful in agriculture, gardening, and automated watering systems. These sensors are easy to interface with microcontrollers



Fig.4.8 Soil Moisture Sensor

3. WORKING

The proposed irrigation system is powered by a **12V solar panel**, which charges a **12V rechargeable battery**. The battery acts as the primary power source and provides uninterrupted operation during night time or cloudy weather. A **DC-to-DC converter** converts the 12V battery supply into a regulated **5V** required for the ATmega328P microcontroller and other electronic components.

The **ATmega328P** acts as the main controller of the system. It continuously receives data from the connected sensors, processes the information, and controls the irrigation process automatically.

The **Soil Moisture Sensor** measures the moisture content of the soil. When the soil moisture falls below the predefined threshold, the microcontroller identifies that irrigation is required and turns **ON the relay**, which activates the **water pump**. Once the soil reaches the desired moisture level, the relay is turned **OFF**, stopping the pump and preventing over-irrigation.

The **Water Level Sensor (SR04)** is used to monitor the water level in the storage tank. If the water level is too low, the system can avoid running the pump without water and can notify the user through the IoT platform.

The **DHT11 sensor** measures the surrounding **temperature and humidity**. These environmental parameters are displayed on the LCD and can also be uploaded to the cloud for monitoring.

The **LDR (Light Dependent Resistor)** measures the ambient light intensity. This information can be used to monitor sunlight conditions or for future implementation of intelligent irrigation scheduling based on daylight.

An **ESP8266 Wi-Fi module** is connected to the ATmega328P for Internet connectivity. It sends sensor readings such as soil moisture, temperature, humidity, water level, and pump status to the **ThingSpeak Cloud**. Users can monitor these parameters remotely through the internet from a mobile phone or computer.

The **16x2 LCD Display** provides real-time information such as soil moisture percentage, temperature, humidity, water level status, light intensity, and the ON/OFF status of the water pump.

Overall, the system performs automatic irrigation based on soil moisture while utilizing **solar energy** as its power source. This reduces manual effort, conserves water, saves electrical energy, enables remote monitoring through IoT, and provides an eco-friendly and efficient solution for smart agriculture.

4. APPLICATIONS

1) Smart Agriculture

Automatically irrigates crops based on soil moisture levels, improving crop yield while reducing manual labor.

2) Water Conservation

Prevents over-irrigation by supplying water only when required, resulting in efficient use of water resources.

3) Remote Monitoring and Control

Farmers can monitor soil moisture, temperature, humidity, water level, and pump status remotely through the IoT (ThingSpeak) platform.

4) Solar-Powered Irrigation in Remote Areas

Uses solar energy to operate the irrigation system, making it suitable for rural and remote locations with limited or unreliable electricity supply.

5. CONCLUSION

The solar-based smart irrigation system successfully demonstrates the integration of IoT, embedded systems, and renewable energy to optimize water usage in agriculture. By leveraging real-time data from soil moisture, temperature, and humidity sensors, the system automates irrigation processes, reducing manual intervention and minimizing human errors. The use of solar energy ensures sustainable operation, particularly in remote areas, while cloud-based platforms provide real-time monitoring, control, and historical data storage, enabling farmers to make informed decisions and improve crop yield. The system proves to be reliable, scalable, and energy-efficient, highlighting its potential to enhance water management practices in agriculture.

5. REFERENCES

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