Smart Solar Photovoltaic Pumping System for Agricultural Irrigation

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Declaration

It is declared hereby that this thesis paper or any part of it has not been submitted to anywhere else for the award of any degree.

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This is to certify that this project is done under my direct supervision. It is fully adequate, in scope & quality as a dissertation for the degree of B.Sc. in Engineering (EEE).

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Abstract

This project aims to develop a Smart Irrigation System using solar-powered components and IoT-based control for efficient agricultural water management. The system leverages an Arduino-compatible NodeMCU board, which integrates Wi-Fi capabilities, and uses various sensors such as a soil moisture sensor, water flow meter, and a 12V water pump controlled by a relay module.

The system is designed to monitor soil moisture levels, flow rate, and the operational status of the irrigation pump, while also enabling remote control via the Blynk mobile application. The Blynk app allows users to monitor real-time data and control the irrigation process remotely, ensuring water is used effectively based on soil moisture levels.

Additionally, the system features a local 16x2 LCD display to show soil moisture percentage and flow rate. By incorporating renewable energy sources, the system aims to provide an energy-efficient solution for agricultural irrigation, reducing water wastage and ensuring optimal crop growth.

This project highlights the integration of IoT, renewable energy, and automation in modern agricultural practices, showcasing the potential for sustainable farming solutions.

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Chapter 1

Introduction

1.1 Introduction

Agriculture forms the backbone of many economies, with irrigation playing a pivotal role in ensuring optimal crop growth and productivity. However, the traditional irrigation systems often face challenges, such as inefficiency, excessive water consumption, and dependency on grid electricity or fossil fuels. To address these challenges, smart, sustainable, and automated solutions are becoming increasingly important. This project, Smart Solar-Powered Irrigation System, combines renewable energy, automation, and IoT (Internet of Things) technologies to provide an efficient, eco-friendly irrigation solution.

The system is powered by solar energy, which not only ensures sustainability but also reduces operational costs and dependency on conventional power sources. Central to this design is the NodeMCU microcontroller, which integrates the functionalities of processing, Wi-Fi communication, and IoT capabilities into a single compact module. The project incorporates various sensors, including a capacitive soil moisture sensor for real-time monitoring of soil conditions and a flow meter to measure water usage. An Arduino-compatible 16x2 LCD display is used to display local data, and the Blynk app provides remote control and real-time monitoring of parameters like soil moisture, flow rate, and motor status via a smartphone.

The system's automation capabilities are managed through the NodeMCU and a relay module, enabling automatic water pump operation based on soil moisture levels. This ensures precise irrigation while preventing water wastage. Users can also control the pump manually via the Blynk app, enhancing flexibility.

This project aims to demonstrate the feasibility of combining renewable energy with IoT to optimize water usage in agriculture. By harnessing solar power, automating irrigation, and enabling remote monitoring and control, this system provides a sustainable and scalable solution to modern agricultural challenges. Furthermore, the design is cost-effective and user-friendly, making it suitable for widespread adoption, especially in regions where power supply is limited or erratic.

1.2 Problem Statement

Agriculture is a critical sector that demands efficient management of resources to ensure sustainability and productivity. One of the primary challenges in agriculture is water management, particularly in regions where water resources are limited or subject to seasonal variations. Traditional irrigation systems often result in over-irrigation or under-irrigation, leading to wasted water, reduced crop yields, and increased operational costs. Additionally, these systems heavily rely on grid electricity or fossil fuels, which can be costly, unsustainable, and inaccessible in remote rural areas.

Farmers face difficulties in monitoring soil moisture levels, managing water usage, and controlling irrigation systems in real-time, especially when working with large or dispersed farmlands. The lack of automation and remote control in conventional systems further complicates the process, leading to inefficiencies and increased labor costs. Moreover, the growing concerns over climate change and energy sustainability necessitate the transition to eco-friendly solutions.

To address these issues, there is a pressing need for a smart, automated irrigation system powered by renewable energy. Such a system should efficiently monitor soil moisture levels, optimize water usage, and provide farmers with the ability to control and monitor irrigation remotely, all while being cost-effective and easy to implement. This project aims to solve these challenges by developing a Smart Solar-Powered Irrigation System, integrating renewable energy, IoT technology, and automation for a sustainable and efficient agricultural solution.

1.3 Objective

- To develop a sustainable irrigation system powered by renewable solar energy, reducing dependency on grid electricity or fossil fuels.
- To optimize water usage in agricultural fields through automated irrigation based on real-time soil moisture data.
- To integrate IoT technology for remote monitoring and control of the irrigation system using the Blynk app.
- To measure and monitor water flow rates for efficient water resource management.

- To enhance user convenience by displaying real-time system data (e.g., soil moisture level, flow rate, motor status) on both a local LCD screen and a smartphone app.

- To automate the water pump's operation based on soil moisture thresholds, reducing human intervention.

- To provide a manual override option for the water pump via the mobile app, ensuring flexibility for farmers.

- To design a cost-effective system suitable for small- to medium-scale agricultural applications, especially in rural or off-grid areas.

- To reduce water wastage and improve crop yield by ensuring precise and timely irrigation.

- To promote the adoption of eco-friendly, smart agricultural technologies for sustainable farming practices.

1.4 Scopes

1. Agricultural Efficiency

- Automates irrigation, ensuring water is supplied based on soil moisture levels.
- Reduces water wastage by providing only the necessary amount of water to crops.
- Increases crop yield by maintaining optimal soil conditions.

2. Cost and Resource Savings

- Reduces manual labor and human intervention in irrigation.
- Saves electricity and water by running the pump only when needed.
- Optimizes resource utilization, which is especially beneficial for small and medium-scale farmers.

3. Real-Time Monitoring

- Provides real-time data on soil moisture levels, flow rate, and motor status via the Blynk app.

- Allows farmers to remotely monitor and control the system, enhancing convenience.
- Displays critical information locally on the LCD for immediate reference.

4. Environmental Impact

- Promotes sustainable agricultural practices by conserving water.
- Reduces carbon footprint by utilizing renewable energy (solar power) for system operation.

5. Renewable Energy Integration

- Uses solar energy for powering the system, making it eco-friendly and suitable for remote areas without access to grid electricity.
- Demonstrates the practical use of renewable energy in agriculture.

6. Scalability and Adaptability

- The system can be scaled up for larger farms by adding more sensors and relays.
- It can be adapted for different soil types, crop requirements, or environmental conditions.
- Allows integration of additional IoT features, such as weather data or advanced analytics.

7. Educational and Research Applications

- Serves as a hands-on project for students and professionals learning about IoT, automation, and renewable energy.
- Can be used as a prototype for research on smart farming techniques.

8. Business Opportunities

- Has potential for commercialization as a low-cost, smart irrigation product.
- Targets small-scale farmers or agricultural companies looking for affordable automation solutions.

9. Remote Area Applications

- Ideal for use in rural and remote areas due to its solar-powered design.
- Enables irrigation in areas with limited access to traditional power or water resources.

10. Integration with Advanced Technology

- Can be integrated with weather forecasting systems to further optimize irrigation schedules.
- Supports potential upgrades like machine learning to predict water requirements or advanced analytics for farm management.

1.5 Methodology

1. Problem Identification

Recognize the need for an automated irrigation system to conserve water, reduce labor, and improve crop yield.

2. Hardware Setup

Select and purchase components: NodeMCU, sensors (soil moisture, flow meter), relay, pump, solar panel, battery, and LCD display.

- Assemble the components:
- Connect sensors to NodeMCU to monitor soil moisture and water flow.
- Connect the relay to control the water pump.
- Use a solar panel and charge controller to power the system.

3. Software Development

- Write and upload the code to the NodeMCU using the Arduino IDE.
- Integrate Blynk library for IoT control and monitoring.
- Program the relay to control the pump based on sensor inputs.
- Configure the Blynk app for real-time monitoring and control via smartphone.

4. Testing and Calibration

- Test the hardware connections to ensure all components are functioning correctly.
- Calibrate the soil moisture sensor and flow meter for accurate readings.
- Verify the pump operation and motor control via relay and the Blynk app.

5. Deployment

- Install the system in the field, ensuring the solar panel and sensors are correctly positioned.
- Monitor performance and make adjustments to ensure efficient operation.

6. Evaluation

- Collect data on water usage, soil moisture levels, and pump activity.
- Analyze the system's effectiveness in optimizing water usage and crop health.

1.6 Sources of Information

- Component Datasheets and Manuals: Official datasheets and technical documentation for components like NodeMCU, moisture sensors, flow meters, relay modules, and charge controllers were consulted for understanding specifications and connections.

- Blynk Documentation: The official Blynk website and developer forums provided guidance on integrating IoT devices with the Blynk app for remote monitoring and control.

- Open-Source Arduino Community: Resources like the Arduino forums, GitHub repositories, and open-source libraries were used to develop and adapt the code for this project.

- IoT and Automation Tutorials: Online tutorials, blogs, and YouTube channels offering practical guides on building smart irrigation systems with NodeMCU.

- Personal Experience and Professional Knowledge: Leveraging expertise in renewable energy, IoT system design, and practical experience with solar projects helped in selecting components and creating a functional system.

1.7 Required Input Data

1. Microcontroller:
- NodeMCU (ESP-12E Module)

2. Sensors:
- Capacitive Soil Moisture Sensor
- YF-S201 Water Flow Meter

3. Actuator:
- 12V Mini Brushless DC Water Pump

4. Relay:
- 4-Channel 5V Relay Module (used to control the water pump)

5. Display:
- 16x2 LCD Module with I2C Interface

6. Power Components:
- 12V 20W Solar Panel
- 12V 5Ah Lead Acid Battery

- 12V PWM Solar Charge Controller

7. Communication Module:

- Built-in Wi-Fi of NodeMCU (for Blynk app control)

8. Other Components:

- Jumper Wires (Male-to-Male, Male-to-Female, Female-to-Female)
- Breadboard
- 8-Channel Logic Level Converter (if required)
- Soldering Iron, Rosin, Lead
- Pipes for Pump, Water Tank, Plastic Tray, Super Glue, Paper Glue, Costape

Software Tools:

- Arduino IDE for coding
- Blynk App for IoT control and monitoring

1.8 Project Outline

Chapter 1- Introduction

Chapter 2- Literature Reviews

Chapter 3- Theoretical Model

Chapter 4- Hardware & Software Development

Chapter 5- Result & Discussions

Chapter 6- Conclusion

Reference Link

Appendix

1.9 Summary

The Smart Solar-Powered Irrigation System integrates solar energy, IoT, and automation to optimize water usage in agriculture. Powered by NodeMCU, it uses sensors to monitor soil moisture and water flow, automates irrigation, and provides remote control via the Blynk app. This cost-effective and eco-friendly solution reduces water wastage, improves crop yield, and is ideal for small-scale farmers in off-grid areas.

Chapter 2

Literature Reviews

2.1 Introduction

Recent advancements in technology have transformed traditional farming, with IoT and solar-powered irrigation systems offering sustainable solutions for efficient water management. This chapter reviews existing studies on automated irrigation, IoT in agriculture, and renewable energy integration, identifying gaps and justifying the need for the proposed Smart Solar-Powered Irrigation System.

2.2 Automatic Irrigation system

Automatic irrigation systems have gained significant attention in modern agriculture due to their ability to optimize water usage and reduce manual intervention. These systems utilize sensors, microcontrollers, and actuators to automate water distribution based on real-time soil moisture levels and environmental conditions. By eliminating guesswork, they ensure precise irrigation, leading to improved crop health and water conservation.

Various studies have demonstrated the effectiveness of automatic irrigation systems in reducing water wastage and increasing efficiency. For instance, soil moisture sensors play a crucial role in detecting moisture levels and triggering the irrigation process automatically. Additionally, integrating flow meters ensures accurate measurement of water usage, helping farmers manage resources effectively.

Traditional irrigation methods often lead to over-irrigation or under-irrigation, negatively impacting crop yield and wasting water. Automatic systems address these challenges by providing timely and adequate water supply tailored to the needs of crops. Moreover, they reduce labor costs and enhance convenience for farmers, especially in large or remote fields.

The integration of automation with renewable energy and IoT further enhances these systems, making them more sustainable and accessible. This literature review explores various advancements in automatic irrigation technologies and their potential to transform modern agriculture.

2.3 NodeMcu

NodeMCU is a low-cost, open-source IoT platform based on the ESP8266 Wi-Fi module. It combines microcontroller functionality with built-in Wi-Fi, making it ideal for IoT applications like smart irrigation systems. With GPIO pins and support for popular programming environments like Arduino IDE, NodeMCU enables seamless integration of sensors, actuators, and IoT platforms like the Blynk app. Its compact design, cost-efficiency, and ease of use make it a popular choice for automation and remote monitoring in agriculture.

2.4 Why NodeMcu

NodeMCU is chosen for this project due to its several advantages that make it highly suitable for IoT-based applications like smart irrigation systems:

1. Built-in Wi-Fi: NodeMCU integrates the ESP8266 Wi-Fi module, allowing easy connection to the internet for remote control and monitoring via IoT platforms such as the Blynk app.

2. Cost-Effective: NodeMCU is affordable, making it a practical option for small- to medium-scale projects without compromising on functionality.

3. Ease of Use: It is compatible with the Arduino IDE, enabling quick programming and development. Its user-friendly interface makes it accessible even for beginners.

4. Compact Design: With a small form factor, NodeMCU fits well into compact systems, making it suitable for projects where space is limited.

5. Versatility: It supports a variety of sensors and actuators, including soil moisture sensors and relay modules, ideal for controlling water pumps and automating irrigation based on real-time data.

6. Community Support: Being widely used in the maker community, NodeMCU has extensive documentation, tutorials, and forums, ensuring ease of troubleshooting and development.

2.5 Soil Moisture Sensor

Soil moisture sensors are essential components in irrigation systems, used to measure the water content in soil. These sensors work by detecting changes in the electrical conductivity or capacitance of the soil, which varies with moisture levels. When the soil becomes dry, the sensor triggers the irrigation system to activate and deliver water. Capacitive soil moisture sensors, known for their durability and accuracy, are commonly used in smart irrigation systems due to their resistance to corrosion and stable performance over time. These sensors help optimize water usage, prevent over-irrigation, and ensure healthy crop growth.

2.6 History of Soil Moisture Sensor

Soil moisture sensors have evolved significantly over the past century. Early methods for measuring soil moisture involved simple techniques like gravimetric and volumetric water content measurements, which were time-consuming and labor-intensive. In the 1950s, electrical resistance-based sensors were introduced, offering a more practical and efficient approach.

By the 1970s, the advent of capacitance and time-domain reflectometry (TDR) sensors allowed for more precise and real-time moisture measurements. Capacitive sensors became particularly popular due to their non-corrosive nature and better durability compared to resistance-based models. In recent years, the development of low-cost, digital soil moisture sensors, particularly using technologies like the capacitive principle, has facilitated their widespread adoption in automated irrigation and smart farming systems. Today, these sensors are key components in precision agriculture, helping optimize water usage and improve crop yields.

2.7 Water Flow Sensor

Water flow sensors are devices used to measure the flow rate of water in a pipe or irrigation system. They typically work by detecting the movement of water through a turbine or using electromagnetic technology to monitor flow. The sensor generates an electrical signal that correlates with the rate of water flow, providing real-time data. This information helps in optimizing water usage, ensuring that the irrigation system delivers the correct amount of water. Flow sensors are crucial in automated irrigation systems to monitor efficiency, prevent wastage, and ensure precise water distribution.

2.8 Relay Module

A relay module is an electrically operated switch used to control high-power devices, such as water pumps, in an automation system. It consists of an electromagnet that opens or closes a set of contacts when an electrical signal is applied. In smart irrigation systems, a relay module allows low-voltage microcontrollers like NodeMCU to control high-voltage equipment (e.g., a water pump) without direct electrical contact. Relay modules provide safety, reliability, and flexibility in switching devices based on sensor data or remote commands, making them essential in automation applications.

2.9 Summary

This chapter reviews key technologies for a Smart Solar-Powered Irrigation System, including automatic irrigation systems that optimize water usage and reduce labor. It discusses NodeMCU for IoT integration, soil moisture sensors for precise irrigation, water flow sensors for monitoring water usage, and relay modules for controlling pumps. These components work together to create an efficient, automated system that enhances resource management and crop productivity.

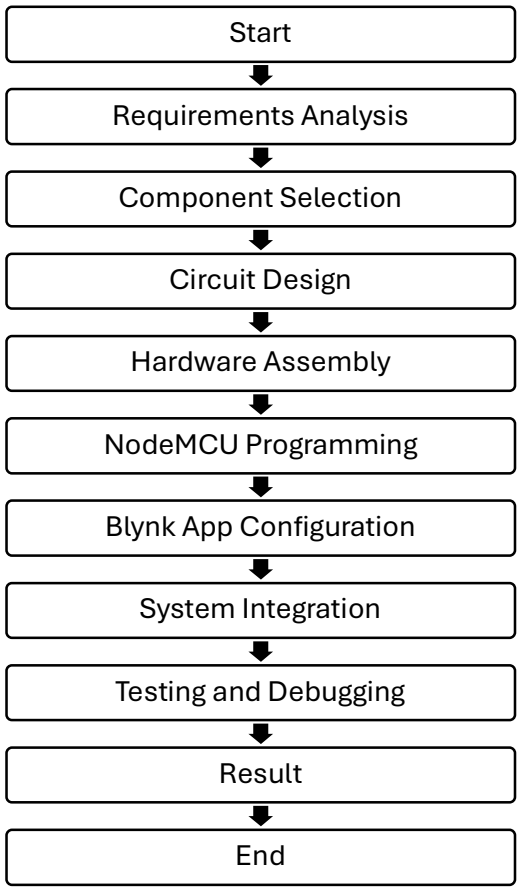
Chapter 3

Theoretical Model

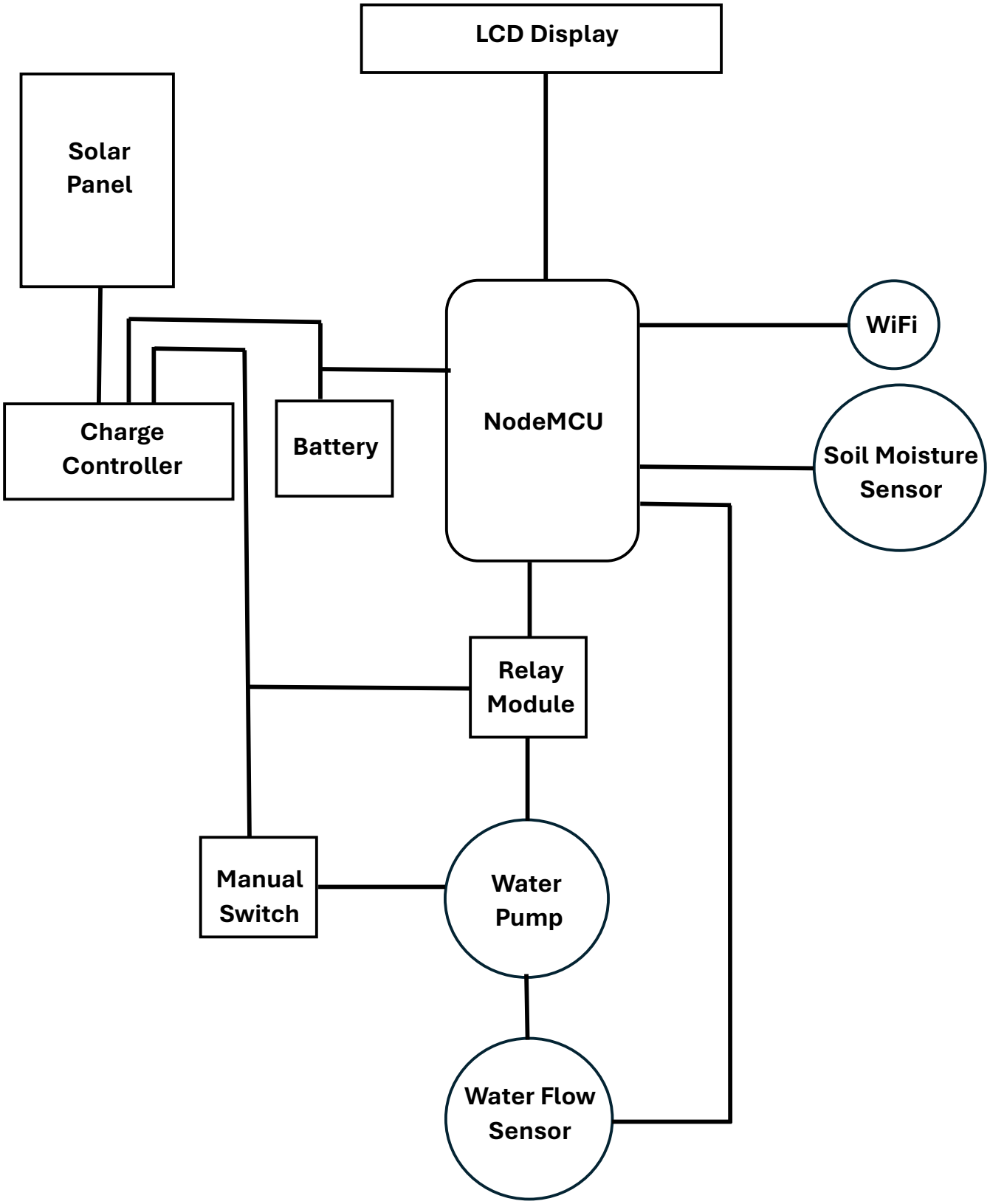
3.1 Introduction

Efficient water management is critical for sustainable agricultural practices, especially in areas facing water scarcity. The integration of renewable energy sources, such as solar power, with automated irrigation systems offers a promising solution to meet these challenges. This project focuses on the design and implementation of a Smart Solar Photovoltaic Pumping System for Agricultural Irrigation. This system leverages solar energy to power a water pump and employs sensors and IoT technology to monitor and control irrigation based on soil moisture levels. This chapter outlines the theoretical framework, including the system's components, flow chart, block diagram, circuit diagram, and working procedure, to provide a comprehensive understanding of its functionality.

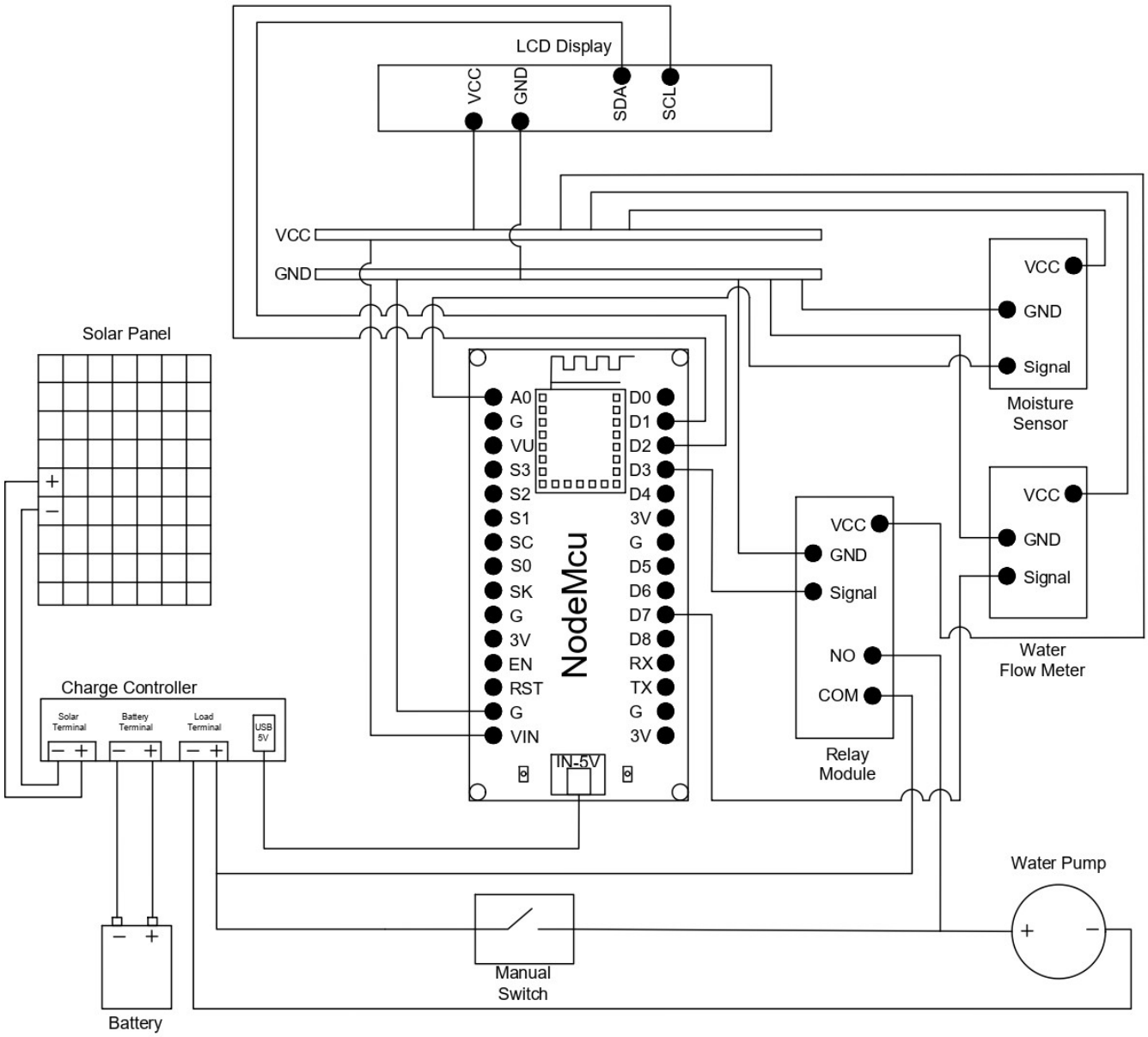
3.2 Flow Chart



3.3 Block Diagram of Smart Solar Photovoltaic Pumping System



3.4Circuit Diagram of Smart Solar Photovoltaic Pumping System



Circuit Diagram

3.5Working Procedure

1. Data Collection

Soil Moisture Sensor:
The capacitive soil moisture sensor continuously measures the soil's moisture content.
It provides an analog signal to the NodeMCU via the A0 pin.
The moisture value is converted into a percentage and displayed for the user to assess the soil's condition.

Flow Meter:
The flow meter measures the water flow rate through the system when the pump is running.
It generates pulse signals that the NodeMCU uses to calculate the flow rate in liters per minute (L/min). This ensures the user knows how much water is being delivered during irrigation.

2. Pump Operation

The user can control the pump based on the moisture levels:

Control via Blynk App:
The Blynk App displays real-time soil moisture levels, water flow rate, and pump status.
The user can press the ON button in the app to start the pump and the OFF button to stop it.
This provides remote control of the pump, making it convenient to operate from anywhere.

Control via Physical Switch:
A physical switch connected to the relay module allows the user to turn the pump ON or OFF directly. This is especially useful in situations where internet or Wi-Fi connectivity is unavailable.

3. System Monitoring

LCD Display:

The local LCD screen shows real-time data
Soil Moisture Level: Displayed as a percentage.
Water Flow Rate: Displayed in liters per minute (L/min).
This provides a simple and reliable way to monitor the system without relying on the app.

Blynk App:

Displays the same data as the LCD but allows remote monitoring and control.
Soil moisture (Virtual Pin V1).
Water flow rate (Virtual Pin V2).
Pump ON/OFF status (Virtual Pin V3).

4. Relay Module for Pump Control

The relay module acts as a switch for the 12V DC pump.
When the user presses ON in the app, the relay is activated, turning the pump ON.
When the user presses OFF in the app, the relay deactivates, stopping the pump.

5. Power Supply

The system is powered by a 12V solar panel that charges a 12V battery through a charge controller.

6. Wi-Fi Connectivity

The NodeMCU connects to the internet via Wi-Fi, enabling real-time communication with the Blynk server.

3.6 Summary

This chapter detailed the theoretical framework of the Smart Solar Photovoltaic Pumping System, which integrates solar power, sensors, and IoT technology to automate agricultural.

Chapter 4

Hardware & Software Development

4.1Introduction

The Smart Irrigation System is designed to optimize water usage for agricultural irrigation by integrating modern hardware and software technologies. The system allows real-time monitoring of soil moisture levels and water flow, enabling users to make informed decisions about irrigation. It uses a relay module to control a 12V DC water pump, which can be operated manually via a physical switch or remotely using the Blynk IoT app. The hardware components include sensors, a NodeMCU microcontroller, a solar-powered battery system, and an LCD display, while the software development revolves around programming the NodeMCU for efficient data processing and user interaction through the Blynkapp.

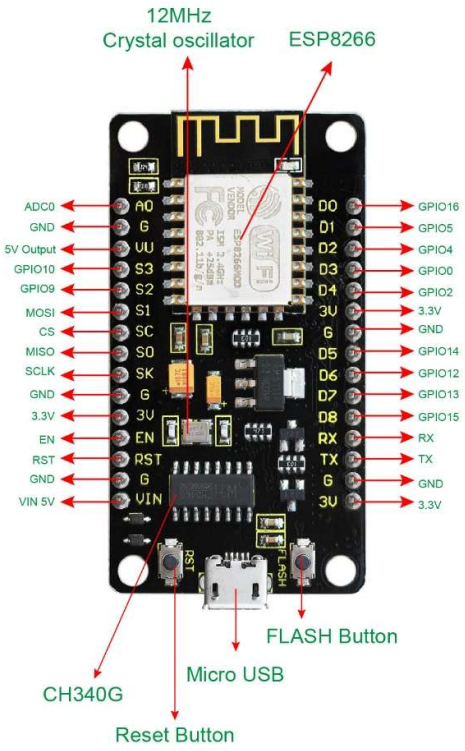
This chapter focuses on the hardware components and their specifications, as well as the software tools and programming used to bring the system to life.

4.2Components Name & Quantity

SL	Name	Description	Qty.	UoM
1	NodeMcu	ESP8266	1	Pcs
2	Soil Moisture Sensor	Capacitive Soil Moisture Sensor	1	Pcs
3	Flow Meter	YF-S201 Water Flow Meter	1	Pcs
4	12V DC Motor (Water Pump)	Mini 12 V Brushless Pump	1	Pcs
5	Relay Module	4 Channel 5V Relay Board Module	1	Pcs
6	Battery	12 V 4.55Ah battery	1	Pcs
7	Solar Panel	12 V 30W Solar Panel	1	Pcs
8	Solar Charge Controller	PWM Charge Controller	1	Pcs
9	Jumper Wires	M to M, M to F, F to F	3	Pcs
10	LCD Display	16X2 Seial LCD Module	1	Pcs
11	Breadboard	MB102 Breadboard (Large)	1	Pcs
12	Cable	1X1 rm Felxible	5	Meter
13	Pipe for Pump		15	Ft
14	Water Tank		1	Pcs
15	Plastic Tray		1	Pcs
16	Paper Glue		1	Pcs
17	Costape		1	Pcs

4.3NodeMcu

NodeMCU is a low-cost, open-source IoT platform based on the ESP8266 Wi-Fi module. It is the core component of the Smart Irrigation System, responsible for collecting sensor data, processing it, and enabling communication with the Blynk IoT app via Wi-Fi. Its ability to support both hardware and software integration makes it ideal for IoT-based automation projects.



4.4Technical Specification of NodeMcu

The NodeMCU module has the following key technical specifications:

- Microcontroller: ESP8266
- Clock Speed: 80 MHz (can be overclocked to 160 MHz)
- Operating Voltage: 5 V & 3.3 V
- Flash Memory: 4MB
- SRAM: 64KB
- GPIO Pins: 17 pins (includes ADC, PWM, I2C, SPI, UART)
- Wi-Fi Standard: IEEE 802.11 b/g/n
- Wi-Fi Security: WPA/WPA2
- ADC (Analog to Digital Converter): 1 channel, 10-bit resolution
- Connectivity: Integrated Wi-Fi for IoT applications
- Programming Language: Lua, Arduino IDE (C/C++)
- Power Input: USB or external 5 V

4.5Pin Description of NodeMcu

NodeMCU is The NodeMCU (ESP8266) development board has multiple pins that serve different purposes. Below is a detailed description of the pins used in this project:

Pin	Description
Vin	Power input pin; can be connected to an external 5V power supply.
3V3	Provides a regulated 3.3V output from the onboard voltage regulator.
GND	Ground pin; used for common ground connections.
D0 (GPIO16)	General-purpose I/O pin; can be used for digital input or output.
D1 (GPIO5)	Used for I2C communication (SCL pin in this project for LCD or other sensors).
D2 (GPIO4)	Used for I2C communication (SDA pin in this project for LCD or other sensors).
D3 (GPIO0)	Can be used for digital input/output or as a boot mode selection pin.
D4 (GPIO2)	Connected to the onboard LED; also used as a general-purpose I/O pin.
D5 (GPIO14)	SPI Clock (SCK); used for serial peripheral interface communication.
D6 (GPIO12)	SPI Master-In-Slave-Out (MISO); used in SPI communication.
D7 (GPIO13)	SPI Master-Out-Slave-In (MOSI); used in SPI communication.
D8 (GPIO15)	SPI Chip Select (CS); can also function as a digital I/O pin.
A0	Analog input pin; used for reading analog signals like soil moisture sensor data.
Tx (GPIO1)	UART Transmit pin; used for serial communication.
Rx (GPIO3)	UART Receive pin; used for serial communication.

Pin Configuration in This Project

- A0: Connected to the soil moisture sensor to read analog values.
- D1 (GPIO5): I2C clock (SCL) for the LCD.
- D2 (GPIO4): I2C data (SDA) for the LCD.
- D3 (GPIO14): Connected to the relay module to control the water pump.
- D7 (GPIO12): Connected to the flow meter for pulse signal input.
- GND: Common ground for all components.
- Vin: Power output for all sensors and relay module. (5V DC)

4.6Soil Moisture Sensor

The Soil Moisture Sensor is used to measure the moisture content in the soil. It has two types of output: an analog output, which provides a voltage value proportional to the moisture level, and a digital output that triggers a high or low signal depending on whether the soil is wet or dry. In this project, we use the analog output to obtain more precise readings of soil moisture levels.



4.7Technical & Pin Description of Soil Moisture Sensor

- Operating Voltage: 3.3V to 5V.
- Output Type: Analog.
- Measuring Range: 0% to 100% soil moisture.
- Sensing Method: Capacitive or resistive.
- Accuracy: ±5% .
- VCC: This pin connects to the power supply
- GND: This pin connects to the ground (GND) of the system.
- AO (Analog Output): This pin provides an analog voltage that corresponds to the moisture level in the soil. It is connected to the A0 pin on the NodeMCU.

4.8Water Flow Meter

The Water Flow Meter is used to measure the amount of water flowing through a pipe. It is essential for monitoring irrigation efficiency and ensuring the system is operating correctly. The flow meter in this project provides data on the water flow rate, which can be used to track the irrigation system's performance and be displayed on the Blynk app.

4.9Technical & Pin Description of Water Flow Meter

- Operating Voltage: 5V DC
- Measuring Range: 1-10 liters per minute (L/min)
- Accuracy: ±1-5%.
- Output Type: Pulse output; the number of pulses generated is proportional to the flow rate.
- Material: Made of durable plastic.



Pin Description:

- VCC: Connects to the power supply (5V).
- GND: Ground pin, connects to the ground (GND) of the system.
- Signal (OUT): This is the pulse output pin.

4.10 Technical & Pin Description of Relay Module

The Relay Module is used to control the 12V DC water pump based on the input from the NodeMCU. A relay acts as a switch that allows a low-voltage signal from the NodeMCU to control a high-voltage device (such as the water pump). This component is critical in turning the pump on or off based on the user's input.

Technical Description of Relay Module

- Operating Voltage: 5V DC (for the relay coil).
- Switching Voltage: Can handle up to 250V AC or 30V DC for switching devices.
- Current Rating: up to 10A for AC or 15A
- Control Pin Type: Low-level trigger (relay activates when the control pin is low).



Pin Description of Relay Module

- VCC: Connects to the 5V supply from the NodeMCU
- GND: Ground pin; connects to the ground of the system.
- IN: Input pin; this is connected to a digital I/O pin on the NodeMCU (such as D3).
- NO (Normally Open): Connects to the water pump.
- COM (Common): Connects to the power supply.

4.11 12 V DC Water Pump

Mini 12 V Brushless Pump: A brushless dc pump is a 12v mini dc motor & water pump that uses magnetic force to rotate its impeller to pressurize and transport water for fluid lifting, booster, and circulation system. It is a kind of typical mechatronic product.



General Specification	
Noise	less than35db
Pump material	ABS Plastic
Condition of use	continuously
Fluids	Water, oil, gasoline, acid and alkali solution.
Working temperature	0 ~ 75c.
Power Consumption	3.6W
Rated Voltage	12V DC
Max Current	350mA
Max flow rate	4L/MIN(1.06G/MIN)
Max Head(lift height)	3M
Water proof class	IP68(can be submersible installed).
Shipment Weight	0.076 kg
Shipment Dimensions	7 × 7 × 5 cm

4.12 12 V 4.5Ah Battery



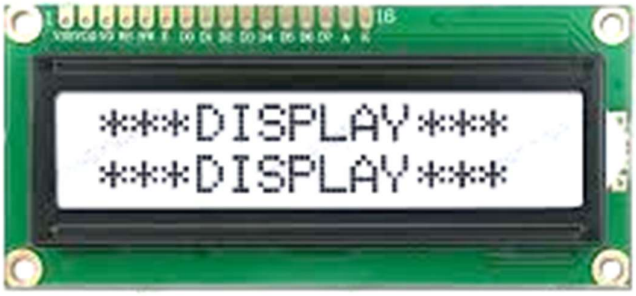
4.13 12 V 30Watt Solar Panel



4.14 10 Amp PWM Charge Controller



4.15 16X2 Serial LCD Module



4.16 Breadboard

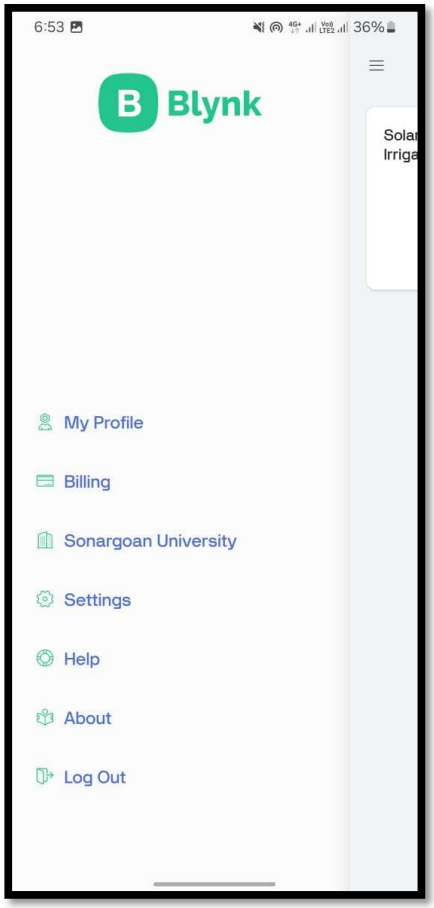


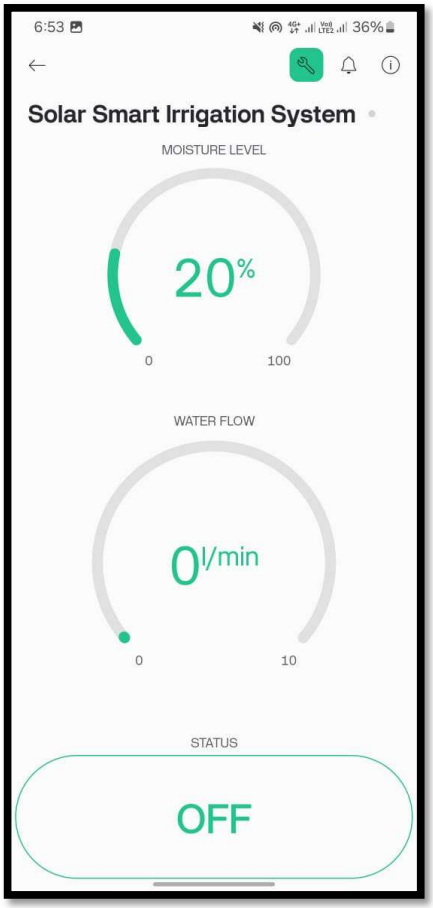
4.17 ON/OFF Switch



4.18 Description of Blynk IoT App

The Blynk IoT app is an easy-to-use platform for building Internet of Things (IoT) projects, allowing you to remotely monitor and control hardware like sensors, relays, or actuators. It's often used in projects involving microcontrollers like Arduino, ESP32, or Raspberry Pi. Blynk provides an intuitive interface for connecting devices via the internet, visualizing sensor data, and controlling hardware remotely.





Steps to Create Project in Blynk IoT App:

1. Create a Blynk Account:

- Download the Blynk IoT app from the Google Play Store or Apple App Store.
- Sign up for an account using your email or Google account.

2. Create a New Project:

- Open the app and tap on the "+" icon to create a new project.
- Choose your device type (e.g., Arduino, ESP32, etc.).
- Select the connection type (e.g., Wi-Fi, Bluetooth, etc.).

3. Design the Dashboard:

After creating a project, On the dashboard where can start designing the user interface.

Add widgets like:

- Button: To control devices (e.g., turning on/off a light).
- Slider: To adjust values (e.g., controlling the brightness of a light).
- Gauge: To display real-time data (e.g., temperature or humidity readings).
- LED: To represent the status of a device (on/off, active/inactive).
- Text display: To show sensor readings.

4. Link Hardware to the App:

Open hardware code (e.g., Arduino IDE for Arduino or ESP32).

Add the Auth Token in code so that hardware can connect to the Blynk app.

4.19 Code for NodeMCU Programming

Code:

```
#define BLYNK_TEMPLATE_ID "TMPL64sQJrCBf"
#define BLYNK_TEMPLATE_NAME "Solar Smart Irrigation System"
#define BLYNK_AUTH_TOKEN "7yowNOrA1OSB4TAvAVMvBhTs4WwoOB6y"

#include <LiquidCrystal_I2C.h>
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

LiquidCrystal_I2C lcd(0x27, 16, 2);

char ssid[] = "Abdullah Al Mamun";
char pass[] = "00000000";

BlynkTimer timer;
bool Relay = 0;

#define sensor A0
#define waterPump D3
#define flowSensorPin D7

volatile int flowCount = 0;
float flowRate = 0;
unsigned long lastFlowTime = 0;
```

```
void IRAM_ATTR flowInterrupt() {
flowCount++;
}

void setup() {
Serial.begin(9600);
pinMode(waterPump, OUTPUT);
digitalWrite(waterPump, HIGH);
pinMode(flowSensorPin, INPUT_PULLUP);
attachInterrupt(digitalPinToInterrupt(flowSensorPin), flowInterrupt, FALLING);

lcd.init();
lcd.backlight();

Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass, "blynk.cloud", 80);

lcd.setCursor(1, 0);
lcd.print("System Loading");
for (int a = 0; a <= 15; a++) {
lcd.setCursor(a, 1);
lcd.print(".");
delay(500);
}
lcd.clear();

timer.setInterval(100L, soilMoistureSensor);
timer.setInterval(1000L, calculateFlowRate);
}

BLYNK_WRITE(V1) {
Relay = param.asInt();

if (Relay == 1) {
digitalWrite(waterPump, LOW);
} else {
digitalWrite(waterPump, HIGH);
}
}

void soilMoistureSensor() {
int value = analogRead(sensor);
value = map(value, 0, 1024, 0, 100);
value = (value - 100) * -1;
```

```
Blynk.virtualWrite(V0, value);
lcd.setCursor(0, 0);
lcd.print("Moisture :");
lcd.print(value);
lcd.print(" ");
}

void calculateFlowRate() {
flowRate = (flowCount / 3);
flowCount = 0;

Blynk.virtualWrite(V2, flowRate);

lcd.setCursor(0, 0);
lcd.print("Moisture : ");
lcd.print(analogRead(sensor));

lcd.setCursor(0, 1);
lcd.print("Flow: ");
lcd.print(int(flowRate));
lcd.print(" L/min");
}

void loop() {
Blynk.run();
timer.run();
}
```

Chapter 5

Result & Discussions

5.1Introduction

This chapter presents the results and discussions based on the design and implementation of the Smart Irrigation System. The system integrates soil moisture monitoring, water flow rate measurement, and automated pump control, all powered by renewable solar energy. It utilizes an Arduino-based platform (NodeMCU), integrated with sensors, relay modules, and the Blynk app, allowing for remote monitoring and control of the irrigation system. The chapter provides insights into the system's performance, its real-time monitoring capabilities, and the overall cost analysis.

5.2Result of the Project

The system functions effectively in real-time irrigation monitoring and control:

Soil Moisture Sensor: The capacitive soil moisture sensor provided accurate readings of soil moisture content, which were displayed both on the local LCD and the Blynk app. The moisture content was successfully measured as a percentage, offering valuable data for irrigation decisions.

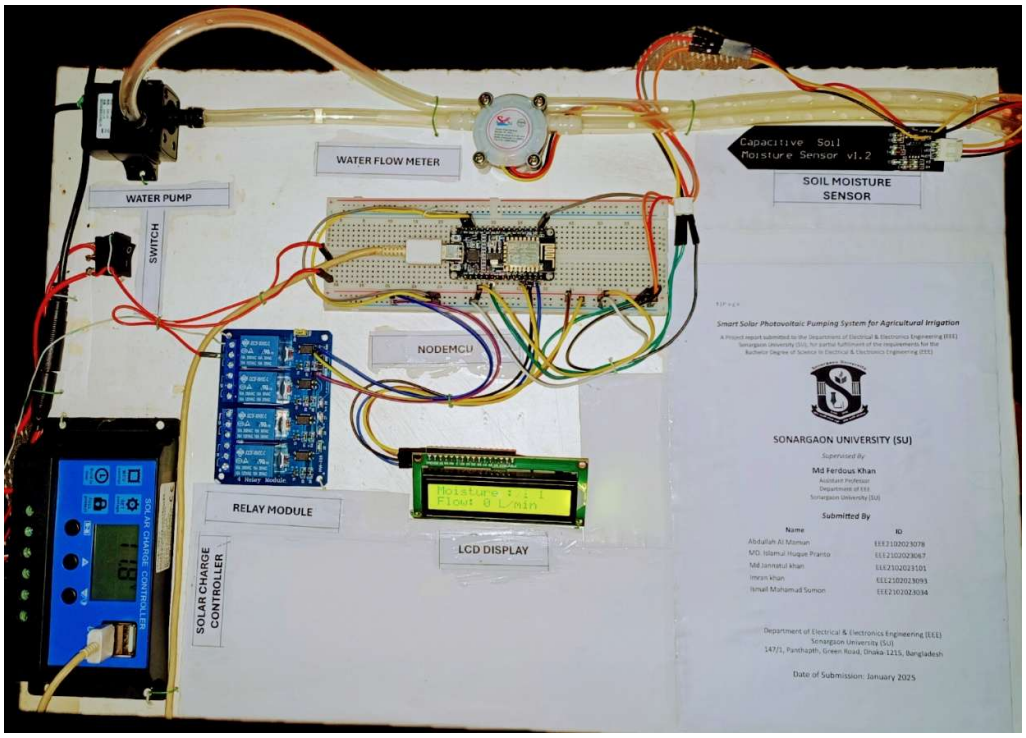
Water Flow Rate Monitoring: The YF-S401 water flow meter accurately measured the water flow rate in liters per minute (L/min), which was displayed on both the LCD and the Blynk app. The flow rate calculation was based on the pulse signals generated by the flow meter, ensuring precise monitoring.

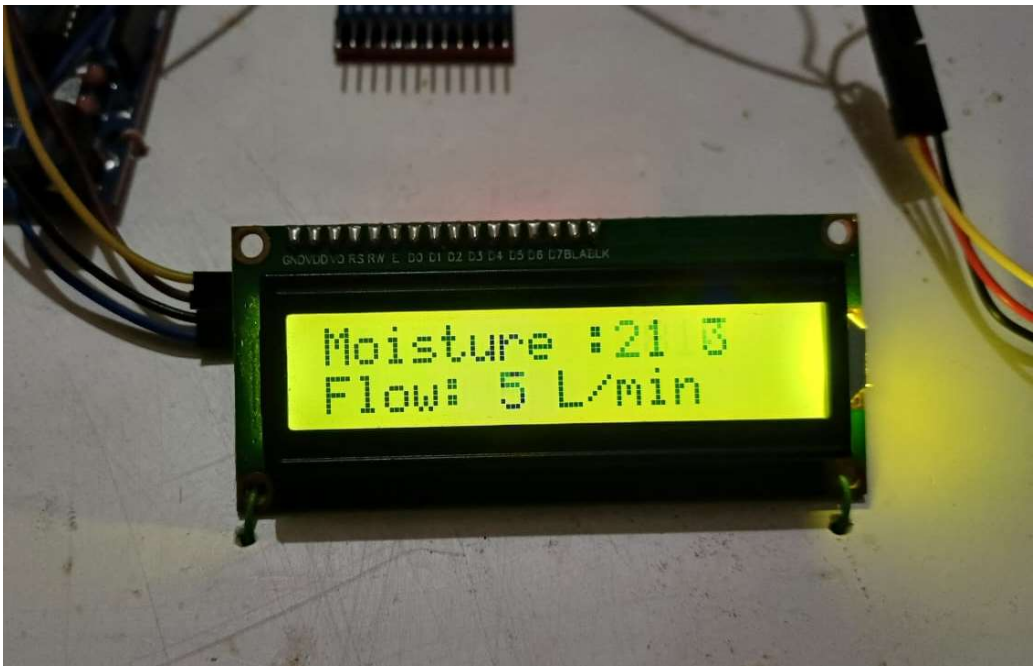
Pump Operation: The system allowed remote control of the pump via the Blynk app, with the user being able to turn the pump ON or OFF based on real-time soil moisture readings. The pump could also be controlled through a physical switch, offering flexibility in case of connectivity issues.

LCD and Blynk App Integration: The local LCD display and the Blynk app were synchronized to show identical data, including the soil moisture level, water flow rate, and the pump's operational status. This made the system user-friendly and accessible remotely.

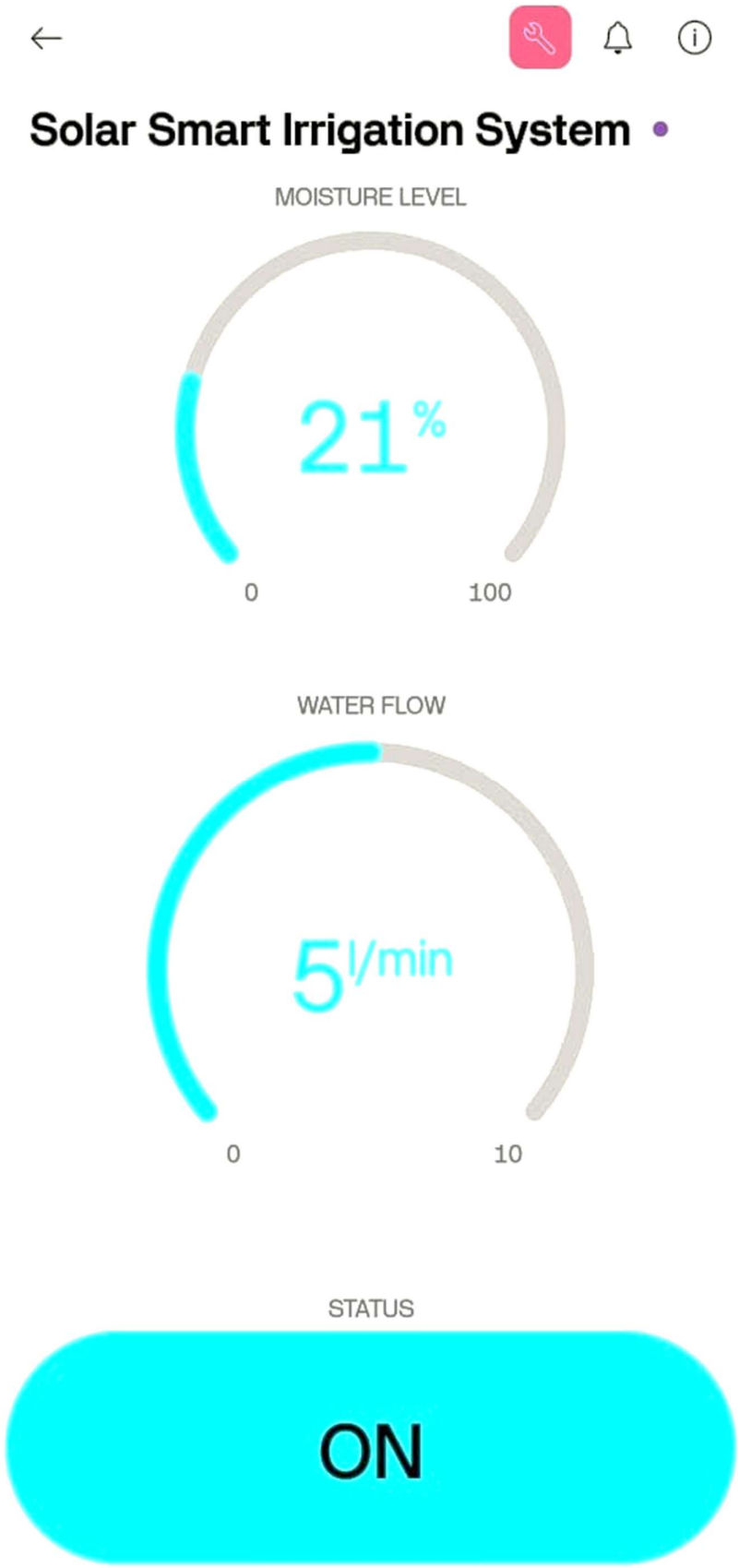
Relay Control: The relay module effectively controlled the 12V DC pump, ensuring reliable switching operations when triggered by either the Blynk app or the physical switch.

5.3Project Physical View





5.4Online Monitoring from Bylnk App



5.5Total Project Cost Details

Smart Solar Photovoltaic Pumping System for Agricultural Irrigation.						
Materials List						
SL	**Name**	**Description**	**Qty.**	**UoM**	**Unit Price**	**Total Price**
1	NodeMcu	ESP8266	1	Pcs	470	470
2	Soil Moisture Sensor	Capacitive Soil Moisture Sensor	1	Pcs	280	280
3	Flow Meter	YF-S201 Water Flow Meter	1	Pcs	430	430
4	12V DC Motor (Water Pump)	Mini 12 V Brushless Pump	1	Pcs	750	750
5	Relay Module (to control the motor)	4 Channel 5V Relay Board Module	1	Pcs	290	290
6	Battery	12 V 5Ah Lead Acid battery	1	Pcs	1000	1000
7	Solar Panel	12 V 20W Solar Panel	1	Pcs	800	800
8	Solar Charge Controller	12 V PWM Charge Controller	1	Pcs	600	600
9	Jumper Wires	M to M, M to F, F to F	3	Pcs	55	165
10	LCD Display	16X2 Serial LCD Module	1	Pcs	340	340
11	Breadboard	MB102 Breadboard (Large)	1	Pcs	160	160
12	Cable	1X1 rm Flexible	5	Meter	20	100
13	Soldering Iron		1	Pcs	200	200
14	Rosin		1	Pcs	10	10
15	Lead		1	Pcs	50	50
16	Pipe for Pump		15	Ft	10	150
17	Water Tank		1	Pcs	150	150
18	Plastic Tray		4	Pcs	120	480
19	Super Glue		5	Pcs	20	100
20	Paper Glue		3	Pcs	20	60
21	Costape		1	Pcs	20	20
22	Transport		1	Job	500	1395
23	Miscellaneous		1	Job	2000	2000
Total Project Cost (BDT)						**10000**

5.6Result Summary of the Project

The Smart Irrigation System achieved the desired goals of automating irrigation control through real-time monitoring of soil moisture and water flow rate. The system is capable of remote control via the Blynk app, making it accessible from anywhere with an internet connection. Additionally, the local LCD display provides essential data without the need for app access, offering a backup in case of connectivity issues.

The system demonstrated accuracy in measuring soil moisture and flow rates, as well as responsiveness in controlling the pump. The integration of solar power and battery storage made the system environmentally friendly and sustainable for long-term use.

The project successfully meets the objectives of enhancing agricultural irrigation through automation and remote monitoring, which will contribute to water conservation and improved crop management. The implementation of the system has proven to be effective in optimizing irrigation efficiency, providing a scalable solution for future applications.

Chapter 6

Conclusion

6.1Conclusion

The Smart Irrigation System developed in this project successfully demonstrates the potential of combining Internet of Things (IoT) technology with renewable energy sources for efficient water management in agricultural practices. By utilizing sensors for soil moisture and water flow rate monitoring, and integrating remote control via the Blynk app, the system provides real-time data for making informed irrigation decisions. The incorporation of solar energy further enhances the system's sustainability, making it suitable for remote and off-grid areas. The system's ability to automate irrigation based on soil moisture levels and monitor its performance remotely ensures more efficient water usage, ultimately contributing to water conservation and optimized crop growth.

6.2Advantages of the project

1. Water Conservation: The system automates irrigation based on real-time soil moisture readings, ensuring water is used only when necessary, which helps in conserving water.

2. Remote Monitoring and Control: The integration with the Blynk app allows users to remotely monitor soil moisture, flow rate, and pump status, providing convenience and flexibility.

3. Sustainability: Powered by solar energy, the system is eco-friendly and sustainable, reducing the dependency on conventional power sources and making it ideal for off-grid locations.

4. Cost-Effective: By minimizing water wastage and optimizing irrigation schedules, the system reduces water bills and operational costs in the long term.

5. User-Friendly: The system's interface, both through the Blynk app and the local LCD display, is intuitive and easy to use for users with minimal technical expertise.

6. Automation: The system automatically controls the irrigation process, reducing human intervention and ensuring timely watering for optimal plant growth.

6.3Limitations of the project

1. Internet Dependency: Although the system offers remote control through the Blynk app, it depends on stable Wi-Fi connectivity. In areas with poor or no internet access, the system's remote features would be ineffective.

2. Power Supply Constraints: While the system is powered by solar energy, prolonged cloudy days or insufficient sunlight might impact the system's operation if battery storage is not adequately sized.

3. Sensor Calibration: The soil moisture sensor might require periodic calibration to ensure accurate readings, as environmental factors can affect its performance over time.

4. Limited Coverage: The current system design is suitable for small-scale or medium-sized agricultural areas. Scaling it for large farms may require additional infrastructure and more advanced sensors.

5. Maintenance: Regular maintenance, such as cleaning the sensors and checking the system's components, is required to ensure the system operates effectively.

6.4Future scope of the project

1. Integration with Weather Forecasting: Future versions of the system could integrate with weather forecasting data to adjust irrigation schedules based on anticipated rainfall, further enhancing water conservation efforts.

2. Scalability: The system could be expanded to cover larger agricultural areas, with multiple sensors and irrigation zones, enabling large-scale irrigation management.

3. Advanced Sensors: Additional sensors such as temperature, humidity, and pH sensors could be incorporated to provide a more comprehensive analysis of the soil condition and enhance the system's effectiveness.

4. AI and Machine Learning Integration: The system could leverage artificial intelligence and machine learning algorithms to predict irrigation needs based on historical data, optimizing irrigation schedules even further.

5. Mobile and Cloud Integration: To make the system more accessible, a cloud-based dashboard and mobile application could be developed to allow users to monitor and control the irrigation system from anywhere in the world.

REFERENCE LINK:

1. Ayad, R. (2015). Internet of Things (IoT) for Smart Agriculture: Applications and Future Directions. Wiley-IEEE Press.

Provides an overview of IoT in agriculture, discussing various sensors, data collection, and remote control systems.

2. Schwager, J., & Bergman, L. (2017). Arduino Projects for Dummies. Wiley.

This book covers various Arduino-based projects, including automation systems and IoT applications like smart irrigation.

3. Tambe, A., & Kumar, P. (2020). Renewable Energy in Agriculture: Harnessing Solar Power for Agricultural Applications. Springer.