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**TITLE: DESIGN AND IMPLEMENTATION OF AUTOMATIC IRRIGATION
UTILIZING DC PUMP**

*FINAL YEAR PROJECT PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE ADVANCED DIPLOMA IN ELECTRICAL TECHNOLOGY*

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KIGALI, OCTOBER .2024

DECLARATION A

This research study is my original work and has not been presented for a degree or any other academic award in any University or Institution of Learning". No part of this research should be reproduced without the authors' consent or that of ULK Polytechnic Institute.

Student name: TWIZEYIMANA JEAN Claude

Signature

Dates:

DECLARATION B

I confirm that the candidate carried out the work reported in this research project under my supervision and it has been submitted with my approval as the UPI supervisor.

Supervisor Name:

Signature:

Dates:

DEDICATION

To my family, whose unwavering support and encouragement have been my greatest source of strength.

To my mentors and colleagues, whose guidance and insights have shaped this project and inspired my passion for innovation.

And to all those who strive to push the boundaries of knowledge and technology, may this work contribute to the advancement of our collective goals.

ACKNOWLEDGEMENT

Firstly, I extend my deepest thanks to my teachers, for their invaluable guidance, expertise, and encouragement throughout the research and development phases. Your insights and constructive feedback were crucial to the success of this project. I am also grateful to my colleagues and peers in the classmate, whose collaboration and shared knowledge greatly enriched my understanding and enhanced the quality of the work. Special thanks to ULK for their assistance with the practical aspects of the design and implementation, and for providing the necessary resources and technical support. Finally, I wish to thank my family and friends for their unwavering support and encouragement. Your belief in me and your patience have been a constant source of motivation. Thank you all for your contributions and support.

ABSTRACT

This paper presents the **design and implementation of an automatic irrigation system utilizing a DC pump** to address the need for efficient water management in agricultural practices. The system aims to optimize water usage while minimizing costs, making it suitable for small to medium-scale farming operations. The design incorporates sensors to measure soil moisture levels and a microcontroller-based control unit to regulate irrigation cycles based on predefined thresholds. A low-cost DC pump is employed for water delivery, ensuring affordability without compromising performance. The system's effectiveness is evaluated through field trials, demonstrating its ability to maintain optimal soil moisture levels and enhance crop yield while minimizing water consumption. Overall, this research contributes to the development of sustainable irrigation solutions accessible to farmers with limited resources.

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LISTOFABBREVIATIONS

PIR	:passive infrared sensor
USB	: universal serial bus
CPU	: central processing unit
RAM	: randomly access memory
PIT	: programmable interval timer
EEPROM	:Electrically-Erasable Programmable Read-Only M

CHAPTER 1: GENERAL INTRODUCTION

1.1 background

The design of an automatic irrigation system has become increasingly significant in modern agriculture and landscaping due to the need for efficient water management. Traditionally, irrigation systems required manual operation, leading to water wastage and inconsistent crop hydration. However, advancements in technology have allowed for the development of automatic systems that use sensors, timers, and controllers to regulate water flow based on environmental conditions, such as soil moisture levels, temperature, and humidity. This not only ensures optimal water usage but also reduces labor and energy costs, while improving crop yield and plant health. Automatic irrigation systems often integrate technologies such as drip irrigation, sprinklers, and smart controllers, making them adaptable to various types of agricultural fields, gardens, and landscapes. With growing concerns over water conservation, the importance of such systems has been highlighted in both urban and rural areas. These systems are crucial in mitigating the effects of climate change, drought, and irregular rainfall patterns, ensuring that water resources are used efficiently and sustainably. Moreover, the integration of IoT (Internet of Things) and automation in irrigation systems is transforming traditional farming practices, making agriculture more sustainable, resource-efficient, and data-driven.

1.2 problem statement

In Rwanda, we strongly face the challenge of irrigation. In this case, it could focus on the lack of affordable and efficient irrigation systems for small to medium-scale farmers, resulting in suboptimal water usage, increased labor requirements, and reduced crop yields. The problem lies in the inefficient and often wasteful use of water resources in traditional irrigation methods, which rely heavily on manual control and human intervention. This leads to several challenges, such as over-irrigation or under-irrigation, inconsistent water distribution, increased labor costs, and significant water wastage. Additionally, with the growing global population, changing climate conditions, and increasing water scarcity, the demand for sustainable and efficient water management in agriculture and landscaping has become more critical. Farmers and land managers face difficulties in optimizing water usage while ensuring healthy crop growth and maintaining soil health. These inefficiencies contribute to reduced crop yields, higher operational costs, and environmental stress. Therefore, there is a pressing need for an automated irrigation system that

can intelligently monitor soil moisture, weather conditions, and plant needs to provide precise, timely, and efficient water distribution, thereby reducing waste and improving agricultural productivity.

1.3 research objectives

1.3.1 Main objectives

The primary objective of this project is to design and implement an automatic irrigation system that leverages a DC pump to enhance water management efficiency in agricultural applications. The system aims to automate the irrigation process by integrating soil moisture sensors, a DC pump, and a control unit to regulate water flow based on real-time soil conditions and environmental factors. By optimizing irrigation scheduling and water distribution, the system seeks to minimize water wastage, reduce manual labor, and improve overall crop health and yield. Additionally, the project aims to ensure the system's reliability and energy efficiency, providing a cost-effective and sustainable solution for modern irrigation needs.

1.3.2 Specific objectives

- Develop and integrate soil moisture sensors into the irrigation system to provide accurate, real-time data on soil moisture levels.
- Create and implement control algorithms that use sensor data to automate the operation of the DC pump.
- Select and configure a DC pump with appropriate flow rate and pressure specifications to meet the irrigation needs of the targeted area efficiently.
- Develop a user-friendly interface for system monitoring and control, allowing users to easily set irrigation schedules, view real-time data, and make manual adjustments if necessary.
- Conduct thorough testing to assess the system's performance in terms of water efficiency, energy consumption, and reliability.
- Analyze the overall cost of implementing and maintaining the automatic irrigation system, comparing it with traditional irrigation methods.

1.4 research questions

- What are the optimal control algorithms for managing the DC pump in response to varying soil moisture levels and weather conditions?

- How does the power consumption of a DC pump compare to other types of pumps in terms of energy efficiency for irrigation purposes?
- How can sensor technology be integrated into an irrigation system to accurately monitor soil moisture and weather conditions?
- What is the most effective automation control method for optimizing water usage in an irrigation system?
- How does the use of automated irrigation systems impact water conservation and crop yield compare to traditional irrigation methods?
- What are the most suitable sensors (soil moisture, temperature, humidity) for ensuring efficient irrigation automation in different types of soil and climates?

1.5 Limitation of study

- The system's performance may vary depending on environmental factors such as soil type, climate, and crop variety.
- The cost-effectiveness of the system may be influenced by factors such as initial investment, maintenance requirements, and energy consumption.
- The study may be limited to a specific geographical region or farming context, potentially limiting the findings of ULK research.

1.6 scope of the study

Designing and prototyping the automatic irrigation system. Testing the system's functionality in a controlled environment. Analyzing the economic feasibility and practicality of implementing the system on small sized farms.

1.7 significance of the study

An automatic irrigation system utilizing a DC pump operating at a moderate cost can significantly enhance water management efficiency. By delivering water directly to the root zone based on soil moisture levels, the system minimizes water wastage and promotes optimal water usage, thereby conserving this precious resource.

The affordability of the system is particularly significant for small to medium-scale farmers who

often face financial constraints. By utilizing readily available components and technologies, your project can provide farmers with a cost-effective solution for automating their irrigation practices, potentially reducing labor costs associated with manual watering. Automated irrigation systems ensure consistent and timely watering, leading to improved crop yield and quality. By maintaining optimal soil moisture levels, the system can mitigate the negative impacts of under or overwatering, promoting healthier plant growth and maximizing agricultural productivity. Sustainable farming practices are essential for preserving natural resources and reducing environmental impact. Your study contributes to the advancement of sustainable agriculture by offering a technology-driven solution that minimizes water usage, reduces reliance on fossil fuels (if solar-powered), and promotes more efficient land utilization.

1.8 organizational of the study

The study was divided into 5 chapters as indicated below:

Chapter one was Introduction composed of Background of the Study, Problem Statement, Objectives of the Study, Research Questions, Significance of the Study, Limitations of the Study, Scope of the Study and the organization of the Study.

Chapter two was Literature Review composed of introduction, theoretical Literature, Empirical Literature, Critical Review and Research Gap Identification, Theoretical Framework, Conceptual Framework and the Summary.

Chapter three was Research Methodology and was made of Introduction, Research Design, Target population, Sample Design, Data Collection Methods, Data Analysis Procedure and Ethical Consideration.

Chapter four was Research Findings and project design and testing.

Chapter five was Summary, Conclusions and Recommendations

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter explores the theoretical framework underlying the design and implementation of an automatic irrigation system utilizing a DC pump. It examines relevant concepts in irrigation technology, the role of DC pumps, and the integration of electronic components to create an efficient and automated irrigation solution. Understanding these principles is crucial for developing a system that meets agricultural needs effectively.

2.2 Theoretical Framework

2.2.1 Principles of Automatic Irrigation Systems

Automatic irrigation systems aim to optimize water usage by automating the irrigation process based on real-time data. The fundamental principles include:

- **Soil Moisture Sensing:** Soil moisture sensors measure the water content in the soil, providing data to determine when irrigation is needed. Accurate moisture sensing helps prevent over-irrigation and ensures plants receive adequate water.

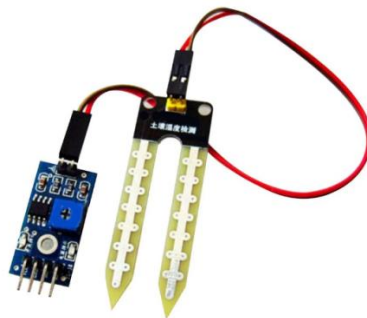


Figure 2.1: moisture sensor

- **Control Algorithms:** Algorithms process sensor data to control the irrigation system. These algorithms use predefined thresholds and schedules to activate or deactivate the pump, ensuring efficient water distribution.
- **Water Delivery Mechanisms:** The system uses a pump to deliver water from a source to the irrigation area. The pump's performance is critical in maintaining consistent water flow and pressure.

2.2.2 Role of DC Pumps in Irrigation

DC pumps are commonly used in irrigation systems due to their efficiency and precise control capabilities. Key theoretical considerations include:

- **Energy Efficiency:** DC pumps are known for their energy efficiency, converting electrical energy into mechanical energy with minimal losses. This efficiency is crucial for reducing operational costs and promoting sustainability.
- **Control Precision:** DC pumps offer precise control over flow rates and pressure, which is essential for adapting to varying irrigation needs. This control enhances the system's ability to respond accurately to sensor inputs.



Figure 2.2: DC pump

2.2.3 Integration of Electronic Components

The integration of electronic components plays a significant role in automating the irrigation process. Key components include:

- **Microcontrollers:** Microcontrollers serve as the central processing unit, interpreting data from sensors and controlling the pump based on predefined algorithms. They enable the automation of irrigation schedules and adjustments.

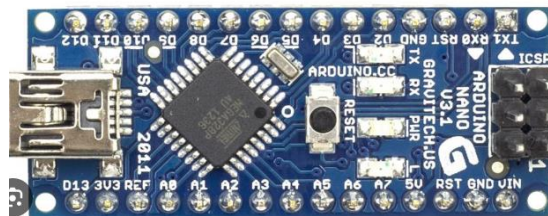


Figure 2.3: microcontroller

- **Relays** control the power supply to the DC pump, allowing the microcontroller to manage pump operation remotely.



Figure 2.4: 5v relay

- **Display Units:** Display units provide user interfaces for monitoring system status and adjusting settings. They enhance user interaction by displaying real-time data and system alerts.

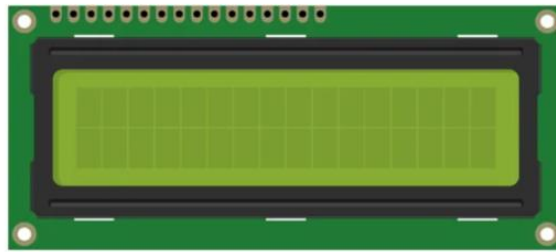


Figure 2.5: 16x2 LCD

- wires

Wires are used to carry electrical current. Electrical current is the flow of electrons and metals have lots of free electrons to do this with.



Figure 2.6: wires

- PCB

Printed circuit boards, also known as PCBs, are the circuit boards used in most electronic devices. The boards both physically and mechanically support the device alongside connecting the electronic components.

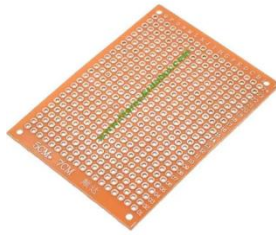


Figure 2.7: PCB

2.3 Needed Electronic Components to run this project

The implementation of an automatic irrigation system utilizing a DC pump requires several electronic components, each serving a specific function within the system:

- **DC Pump:** The primary component responsible for delivering water to the irrigation area. Choose a pump with suitable flow rate and pressure specifications for the application.
- **Soil Moisture Sensors:** Devices that measure the water content in the soil and provide input to the control system. Common types include capacitive and resistive sensors.
- **Microcontroller Arduino nano:** A programmable device that processes sensor data, executes control algorithms, and manages the operation of the pump.
- **Relay Module:** A module used to switch the DC pump on and off based on commands from the microcontroller. It ensures safe and reliable control of the pump's power supply.
- **Power Supply:** Provides the necessary electrical power to the DC pump and other components. Ensure the power supply is compatible with the voltage and current requirements of the system.
- **Display Unit:** A screen or interface 16x2 LCD for presenting real-time information about soil moisture levels, pump status, and system settings.
- **Connectors and Wiring:** Necessary for connecting various components and ensuring proper electrical connections within the system.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research methodology employed in the design and implementation of an automatic irrigation system utilizing a DC pump. It provides a comprehensive overview of the research design, population, sample size, sampling procedures, research instruments, and methods for data collection and analysis. The aim is to ensure a systematic and rigorous approach to developing the irrigation system, addressing all relevant aspects from design to evaluation.

3.2 Research Design

The research design for this project adopts a mixed-methods approach, combining both experimental and qualitative research methods:

- **Experimental Design:** Involves the practical implementation of the irrigation system, including the design and integration of electronic components, testing of the DC pump, and evaluation of system performance under various conditions.
- **Qualitative Research:** Includes analyzing user feedback, reviewing existing irrigation technologies, and assessing system usability and effectiveness.

3.3 Research Population (how to carry out this project)

The research population consists of:

- **Electronic Components:** Various types of DC pumps, soil moisture sensors, microcontrollers, and other related electronic components used in the irrigation system.
- **Agricultural Fields or Test Beds:** Areas where the automatic irrigation system will be tested and evaluated for performance and effectiveness.

3.4 Sample Size

The sample size for this research includes:

- **Components:** A minimum of two different DC pumps and soil moisture sensors to compare performance and reliability.
- **Test Sites:** At least two different agricultural test beds or field setups to evaluate system performance in varied conditions.

3.5 Sampling Procedure

The sampling procedure involves:

- **Component Selection:** Choosing electronic components based on specifications and compatibility with the irrigation system design. Components are selected from reputable suppliers to ensure quality and reliability.
- **Test Site Selection:** Identifying and preparing test sites that represent different soil types and environmental conditions to evaluate the system's effectiveness comprehensively.

3.6 Research Instrument

The research instruments used in this project include:

- **Soil Moisture Sensors:** For measuring soil moisture levels and providing data for system control.
- **DC Pump:** For delivering water based on control signals.
- **Microcontroller:** For processing sensor data and controlling the pump.
- **Measurement Tools:** Such as multimeters and oscilloscopes for testing electrical characteristics and system performance.
- **User Interface:** For monitoring and adjusting system settings.

3.7 Choice of the Research Instrument

The choice of research instruments is based on their suitability for achieving the project's objectives:

- **Soil Moisture Sensors:** Selected for their accuracy and reliability in measuring soil moisture.
- **DC Pump:** Chosen for its energy efficiency and control capabilities.
- **Microcontroller:** we used arduino nano for its versatility and ease of programming, essential for automating the irrigation system.
- **Measurement Tools:** Used to ensure precise evaluation of electrical and performance parameters.

3.8 Validity and Reliability of the Instrument

- **Validity:** Ensures that the research instruments accurately measure the parameters they are intended to. For example, soil moisture sensors must accurately reflect soil conditions, and the DC pump must deliver the specified flow rate and pressure.
- **Reliability:** Refers to the consistency of measurements and results. Regular calibration of sensors, thorough testing of the pump, and consistent programming of the microcontroller contribute to the reliability of the system.

3.9 Data Gathering Procedures

Data gathering involves:

- **Component Testing:** Collecting data on the performance of DC pumps and soil moisture sensors through controlled experiments.
- **System Operation:** Monitoring and recording data from the irrigation system during real-world application at test sites, including water usage, soil moisture levels, and pump operation.
- **User Feedback:** Gathering qualitative data from users regarding system ease of use, effectiveness, and any issues encountered.

3.10 Data Analysis and Interpretation

Data analysis includes:

- **Performance Evaluation:** Analyzing quantitative data on water distribution, energy consumption, and system efficiency. Statistical methods are used to assess the performance of different components and configurations.
- **Comparative Analysis:** Comparing the performance of the automatic irrigation system with traditional irrigation methods and other automated systems.
- **Interpretation:** Drawing conclusions based on data analysis to determine the effectiveness of the system and identify areas for improvement.

3.11 Ethical Considerations

Ethical considerations include:

- **Integrity:** Ensuring accurate and honest reporting of data and findings.

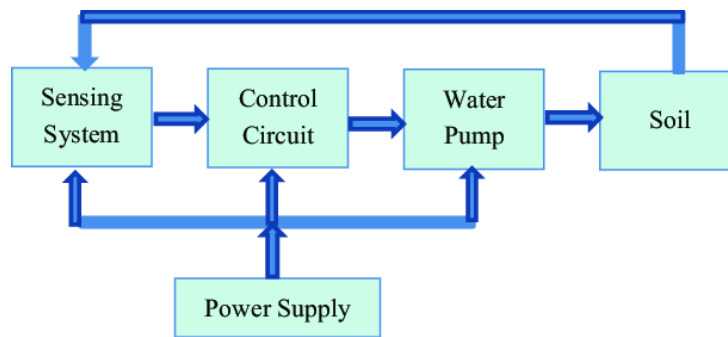
- **Safety:** Adhering to safety protocols during experimentation and system implementation to prevent harm or damage.
- **Confidentiality:** Protecting sensitive data and information related to system design, performance, and user feedback.
- **Environmental Impact:** Considering the environmental implications of system implementation and striving to minimize any negative effects.

CHAPTER 4: SYSTEM DESIGN ANALYSIS AND IMPLEMENTATION

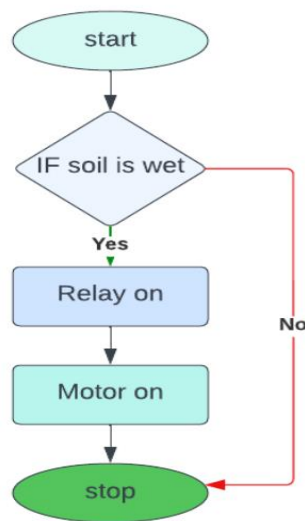
4.1 Introduction

This chapter outlines the design, working principle, and implementation of an automatic irrigation system utilizing a DC pump. It covers the detailed circuit design, the role of each component, and how they work together to achieve efficient and automated irrigation. Understanding the functioning of the system is crucial for evaluating its performance and effectiveness in real-world applications.

4.1 Block diagram



4.2 Flowchart



4.3 circuit diagram components

The automatic irrigation system operates based on real-time soil moisture data to control the DC pump and manage water distribution. The core principle involves:

- **Soil Moisture Sensing:** Soil moisture sensors continuously measure the water content in the soil. When the moisture level falls below a predefined threshold, the sensors signal the control unit to activate the irrigation process.
- **Control Unit:** The control unit, typically a microcontroller, processes the data from the soil moisture sensors. It executes control algorithms to determine when and for how long the DC pump should operate.
- **DC Pump Operation:** The microcontroller sends a signal to the relay module to switch the DC pump on or off. When activated, the pump draws water from a source and delivers it to the irrigation area according to the control instructions.
- **Feedback Mechanism:** The system continuously monitors soil moisture levels and adjusts the pump operation as needed to maintain optimal soil conditions.

4.3 Circuit Design components

The circuit design of the automatic irrigation system includes several key components, each serving a specific function:

4.3.1 Components and Their Functions

- **Soil Moisture Sensors:** These sensors detect the soil's water content and provide analog or digital signals to the microcontroller. Common types include capacitive sensors, which offer high accuracy and durability.
- **Microcontroller:** The microcontroller acts as the central processing unit. In this project we used arduino nano that receives input from the soil moisture sensors, processes the data, and executes control algorithms to manage the DC pump. It also interfaces with other components such as relays and display units.

- **Relay Module:** The relay module acts as a switch to control the power supply to the DC pump. The microcontroller sends a signal to the relay to either allow or cut off electrical current, thereby controlling the pump's operation.
- **DC Pump:** The DC pump is responsible for moving water from the source to the irrigation area. It is chosen based on flow rate, pressure requirements, and energy efficiency. The pump is powered through the relay module, which ensures controlled operation.
- **Power Supply:** Provides the necessary electrical power to the entire system, including the DC pump, microcontroller, and sensors. It must match the voltage and current requirements of the components.
- **Display Unit:** The display unit LCD provides real-time information about soil moisture levels, system status, and pump operation. It allows users to monitor and adjust settings as needed.

4.3.2 Circuit Diagram

A typical circuit diagram for the automatic irrigation system includes:

- **Soil Moisture Sensor Circuit:** Connected to the analog input pins of the microcontroller.
- **Microcontroller Circuit:** Includes connections to the relay module, power supply, and display unit.
- **Relay Module Circuit:** Connected to the DC pump and controlled by the microcontroller.
- **Power Supply Circuit:** Providing power to the microcontroller, relay module, and sensors.

4.3.1 charging circuit diagram

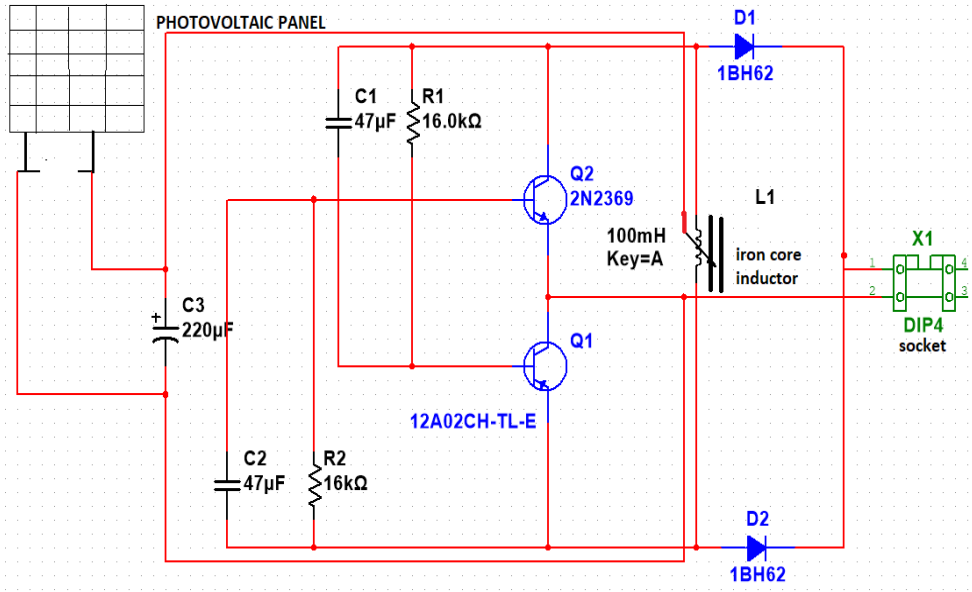


Figure 4.1: Solar charging circuit

4.3.1 Control Circuit diagram

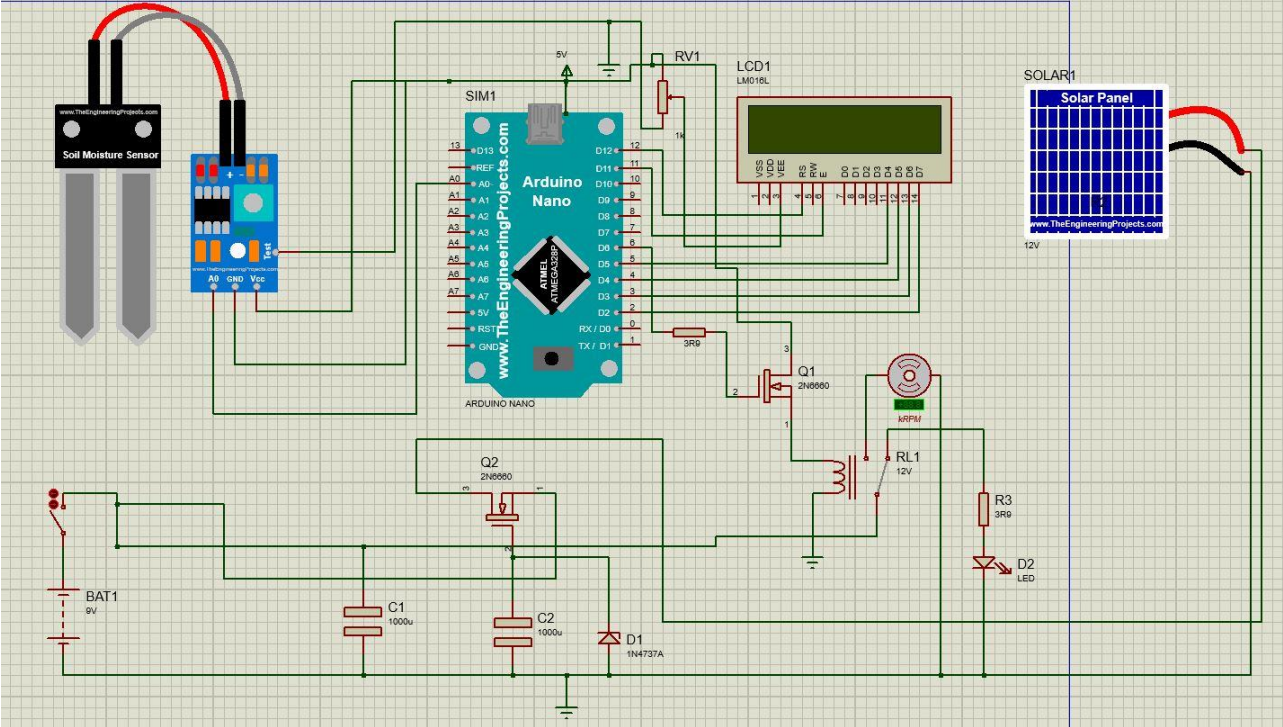


Figure 4.1: Project control circuit



Project picture

Creating an automatic irrigation system using an Arduino Nano, moisture sensor, solar panel, and other essential components is an excellent project for efficiently managing water usage in agricultural setups. Below is a comprehensive guide covering the necessary components, their roles, and the working principle of the system.

Components Required

- ✓ **Arduino Nano:** The microcontroller that serves as the brain of the system, processing sensor data and controlling actuators.
- ✓ **Soil Moisture Sensor:** Detects the moisture level in the soil to determine when irrigation is needed.

- ✓ **Solar Panel:** Provides renewable energy to power the system, enhancing sustainability.
- ✓ **Battery** Stores energy from the solar panel to power the system during low sunlight or nighttime.
- ✓ **Charge Controller:** Manages the power flow from the solar panel to the battery, preventing overcharging and deep discharging.

- ✓ **Water Pump or Solenoid Valve:** Controls the flow of water for irrigation. A pump is used for pumping water from a source, while a solenoid valve can control water flow from a pressurized source.
- ✓ **Relay Module:** Acts as an electrically operated switch to control the high-power pump or valve using the low-power signals from the Arduino.
- ✓ **Diodes** Prevents backflow of current, especially important in solar charging circuits.
- ✓ **Voltage Regulator (if necessary):** Ensures the Arduino and sensors receive the correct voltage.
- ✓ **Resistors and Capacitors:** For sensor signal conditioning and noise reduction.
- ✓ **Connecting Wires on PCB:** For establishing connections between components.
- ✓ **Enclosure:** To protect the electronics from environmental factors.

Working principle

- **Solar Panel:** Captures sunlight and converts it into electrical energy.
- **Charge Controller:** Regulates the voltage and current coming from the solar panel to the battery, ensuring efficient and safe charging.
- **Battery:** Stores excess energy generated by the solar panel, providing power during periods without sunlight.
- **Voltage Regulation:** If the solar panel or battery voltage exceeds the required operating voltage for the Arduino and sensors, a voltage regulator ensures a stable power supply.

2. Sensing Soil Moisture

- **Soil Moisture Sensor:** Placed in the soil, it measures the volumetric water content by detecting the dielectric constant of the soil, which changes with moisture levels.

- **Analog/Digital Output:** Depending on the sensor type, it provides an analog voltage proportional to moisture or a digital signal indicating dry/wet conditions.

3. Control Logic with Arduino Nano

- **Data Processing:** The Arduino Nano reads the moisture sensor's data at regular intervals.
- **Decision Making:** Based on predefined moisture thresholds, the Arduino decides whether irrigation is necessary.
- **Actuation Control:** If irrigation is needed, the Arduino sends a signal to the relay module to activate the pump or open the solenoid valve.

4. Water Delivery System

- **Relay Module:** Acts as a switch controlled by the Arduino to handle the higher current required by the pump or valve.
- **Pump/Solenoid Valve Activation:** Upon receiving the signal from the relay, the pump starts operating to supply water, or the solenoid valve opens to allow water flow.
- **Watering Duration:** The Arduino can control how long the pump runs or the valve remains open, optimizing water usage based on soil moisture readings.

5. Safety and Efficiency Features

- ✓ **Feedback Mechanism:** Optionally, additional sensors (like flow meters) can provide feedback to the Arduino for more precise control.
- ✓ **Manual Override:** Incorporating manual switches allows for manual control of the irrigation system if needed.
- ✓ **Error Handling:** The system can include alerts (LEDs) to indicate low battery, sensor failure, or pump issues.

Basic Circuit Diagram Overview

- ✓ **Power Section:**
 - Solar Panel → Charge Controller → Battery → Voltage Regulator → Arduino Nano and Sensors.

- ✓ **Control Section:**
 - Arduino Nano connected to Soil Moisture Sensor (analog/digital pins).
 - Arduino Nano connected to Relay Module (digital pin).
- ✓ **Actuator Section:**
 - Relay Module controls the Pump or Solenoid Valve connected to the water source.

Sample Circuit Connections

- ✓ **Soil Moisture Sensor:**
 - VCC → 5V (from Arduino)
 - GND → Ground
 - Signal → A0 (Analog Pin on Arduino)
- ✓ **Relay Module:**
 - VCC → 5V (from Arduino)
 - GND → Ground
 - IN → D2 (Digital Pin on Arduino)
 - COM and NO (Normally Open) terminals connected to the pump's power line.
- ✓ **Pump/Solenoid Valve:**
 - Positive from power source → COM of Relay
 - NO of Relay → Pump/Vale Positive
 - Pump/Vale Negative → Ground
- ✓ **Power Supply:**
 - Solar Panel connected to Charge Controller.
 - Charge Controller connected to Battery.
 - Battery connected to Voltage Regulator (if needed).
 - Regulated Power → Arduino and other components.

4.4 Design Specifications

- **Soil Moisture Sensors:** Designed for accurate moisture measurement, with a sensitivity range suited to the soil types in the test area.

- **Microcontroller:** Chosen for its processing power and compatibility with sensors and control algorithms.
- **Relay Module:** Rated to handle the current and voltage requirements of the DC pump.
- **DC Pump:** Selected based on required flow rate and pressure, with considerations for energy efficiency.
- **Power Supply:** Capable of providing stable voltage and current to all components

4.5 Implementation

4.5.1 Assembly

- **Component Integration:** Assemble the circuit by connecting soil moisture sensors, the microcontroller, the relay module, and the DC pump according to the circuit diagram. Ensure all connections are secure and correctly oriented.
- **Programming:** Upload control algorithms to the microcontroller to process sensor data and manage the pump operation.

4.5.2 Testing

- **Initial Testing:** Verify that the circuit operates correctly by checking the functionality of each component individually.
- **System Testing:** Test the complete irrigation system in a controlled environment to ensure it responds accurately to soil moisture levels and operates the DC pump as intended.

4.5.3 Calibration

- **Sensor Calibration:** Adjust the sensor thresholds to ensure accurate moisture level detection.
- **Pump Calibration:** Fine-tune the pump operation to achieve the desired flow rate and pressure.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter provides a summary of the key findings from the design and implementation of the automatic irrigation system utilizing a DC pump. It draws conclusions based on the research, testing, and evaluation of the system. Additionally, it offers recommendations for future improvements and applications.

5.2 Conclusions

The implementation of the automatic irrigation system using a DC pump has demonstrated several significant benefits and findings:

- **Enhanced Efficiency:** The system effectively automates the irrigation process, leading to improved water management. By integrating soil moisture sensors and control algorithms, the system ensures that water is applied precisely when needed, reducing waste and optimizing usage.
- **Energy and Cost Savings:** The DC pump's energy efficiency contributes to lower operational costs compared to traditional irrigation methods. Its precise control capabilities also help in reducing overall energy consumption.
- **System Reliability:** The design and components used in the system have proven to be reliable in maintaining consistent irrigation performance. The integration of soil moisture sensors and a microcontroller ensures that the system adapts to varying soil conditions and maintains effective irrigation.
- **User-Friendly Operation:** The inclusion of a display unit and user interface allows for easy monitoring and adjustment of the system settings. This enhances the user experience and facilitates better management of irrigation schedules.
- **Practical Application:** The system has shown to be practical and scalable for various agricultural settings. The flexibility in component selection and configuration allows for customization based on specific irrigation needs and environmental conditions.

5.3 Recommendations

Based on the findings from this project, the following recommendations are proposed:

- **Component Optimization:** Further research into optimizing the selection of soil moisture sensors and DC pumps can enhance system performance. Consideration of factors such as sensor accuracy, durability, and pump efficiency can lead to more effective and cost-efficient solutions.
- **System Expansion:** Explore the potential for integrating additional features such as weather forecasting data or remote monitoring capabilities. Incorporating these elements can further improve the system's adaptability and effectiveness in different environmental conditions.
- **Scalability:** Investigate methods for scaling the system for larger agricultural operations. This includes evaluating the performance of multiple DC pumps in parallel or designing modular systems that can be expanded based on the irrigation area.
- **User Training:** Provide training and support for users to maximize the benefits of the system. This includes guidance on system setup, maintenance, and troubleshooting to ensure optimal performance and longevity.
- **Environmental Impact:** Continue to assess the environmental impact of the irrigation system, focusing on water conservation and energy usage. Implement strategies to minimize any negative effects and promote sustainable practices in agriculture.
- **Future Research:** Encourage further research into advanced control algorithms and sensor technologies. Innovations in these areas could lead to more sophisticated irrigation systems with enhanced capabilities and efficiency.

REFERENCES

1. Building Internet of Things with the Arduino by Charalampos Doukas (CreateSpace Independent Publishing Platform, 2012) .
2. Architecting the Internet of Things by Dieter Uckelmann, Mark Harrison (Springer, 2011) .
3. Getting Started with the Internet of Things: Connecting Sensors and Microcontrollers to the Cloud by Cuno Pfister (O'Reilly, 2011)
4. Kincaid, D.C. and Heermann, D.F. 1974. i using a programmable calculator. USDA, Agricultural Research Service, ARS-NC-12. US Government Printing Office, Washington DC.
5. Kindsvater, C. E. and R.W. Carter. 1957 of rectangular thin-plate weirs. J. Hydraulics Div. ASCE, 83(HY6), Paper 1453.
6. Kundu, S.S. and Skogerboe, G.V. 1980. Field evaluation methods for measuring basin irrigation performance. Technical Report No. 59, Research Project, Colorado State University, Fort Collins, Colorado.
7. Ley, T.W. 1980. Sensitivity of to field and operation variables. MS Thesis, Department of Agricultural and Chemical Engineering, Colorado State University, Fort Collins, Colorado. Unpublished document. 174p.
8. Malano, H.M. 1982. Comparison of the under continuous and surge flow. MS Thesis. Utah State University, Logan, Utah. Unpublished document.
9. Marr, J.C. 1967. Grading land for. Circular 408, California Agricultural Experiment Station, University of California, Davis, California.
10. Merriam, J.L. 1960. Field method of soil moisture for irrigation. Trans. ASAE 3(1):31-32.
11. Merriam, J.L. and Keller, J. 1978. Farm irrigation system evaluation: A guide for management. Department of Agricultural and, Utah State University, Logan, Utah.
12. Reddell, D.L. and Latimer, E.A. 1986. feedback irrigation system (ARFIS). Paper 86-2578 presented at the Winter Meeting of ASAE, Chicago, Illinois.
13. Salazar, L.J. 1977. Spatial distribution of applied water in surface irrigation. MS Thesis, Department of Agricultural Engineering, Colorado State University, Fort Collins, Colorado. Unpublished document. 154p.

Appendices

Project code

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);
const int AirValue = 600;
const int WaterValue = 310;
const int ThresholdValue = 484;
int soilMoistureValue = 0;
const int RelayPin = 6;

void setup()
{
  Serial.begin(9600);
  lcd.begin(16, 2);
  pinMode(RelayPin, OUTPUT);
  digitalWrite(RelayPin, HIGH);
}

void loop()
{
  soilMoistureValue = analogRead(A0);
  Serial.println(soilMoistureValue);

  lcd.setCursor(0, 0);
  lcd.print("IRRIGATION: ");
  float moisturePercentage = map(soilMoistureValue, AirValue, WaterValue, 0, 100);
  lcd.print(moisturePercentage, 0);
  lcd.print("%");

  int upperLimit = ThresholdValue + 0.1 * (AirValue - WaterValue);
  int lowerLimit = ThresholdValue - 0.1 * (AirValue - WaterValue);
```

```

if (moisturePercentage < 30.0)
{
    digitalWrite(RelayPin, LOW);
    lcd.setCursor(0, 1);
    lcd.print("Pump: ON ");
}
else if (moisturePercentage > 70.0)
{
    digitalWrite(RelayPin, HIGH);
    lcd.setCursor(0, 1);
    lcd.print("Pump: OFF");
}
else
{
    lcd.setCursor(0, 1);
    lcd.print("Pump: ");
    if (digitalRead(RelayPin) == LOW)
    {
        lcd.print("ON");
    }
    else
    {
        lcd.print("OFF");
    }
}

```

Appendices