IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 11, Issue 6, June 2024

DOI: 10.17148/IARJSET.2024.11617

SMART IRRIGATION SYSTEM USING IOT

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Abstract: This abstract examines how important it is for technical innovation to improve agricultural practices and handle water scarcity issues, especially in the area of irrigation systems.. The integration of Internet of Things and sensor systems has emerged as a promising solution to optimize water management and improve operational efficiency in agriculture. However, successful implementation of SMART IRRIGATION SYSTEMS requires careful consideration of research and development (R&D) efforts to identify inefficiencies, focus about administration and security issues, and enhance security measures to safeguard system integrity. By adhering to these recommendations, organizations can leverage smart irrigation systems to mitigate water stress, improve crop yields, and foster sustainable agricultural practices in the face of evolving environmental challenges.

I. INTRODUCTION

India's rural economy is mostly reliant on agriculture, which helped to develop the country. In essence, the monsoons—which supply little water—are what sustain agriculture. Irrigation systems are employed in the field of agriculture to address this problem.

Water will be applied to the agricultural field using this gadget based on the kind of soil. Fertility and moisture content of the soil are important factors in agriculture. There are now many different irrigation techniques available to reduce the need for rain. This type of technology has an on/off schedule and runs on electricity. This article discusses how to use IOT to build a SMART IRRIGATION SYSTEM.

1.1 OBJECTIVES AND METHODOLOGY:

Maximize Water Efficiency
The system adjusts watering schedules dynamically based on real-time data from soil moisture sensors, weather forecasts, and crop water requirements in order to optimize the use of water in agricultural irrigation.

Improve Crop Yields
The system aims to increase crop yields through ensuring that crops are given the correct quantity of water when it is needed. This involves preventing both under-irrigation, which can lead to stunted growth, and over-irrigation, which can result in waterlogged soil and nutrient leaching.

Real-time Monitoring and Control
Give farmers access to an intuitive user interface so they can monitor soil moisture levels, weather, and irrigation procedures in real time. The ability to remotely regulate irrigation systems will enable farmers to make well-informed decisions and modifications without having to constantly be present in the field.

Reduce Operational Costs
Minimize manual labour0020and resources associated with traditional irrigation methods. The system aims to reduce the need for manual intervention, such as routine inspections and adjustments, leading to operational cost savings for farmers.

Enhance Environmental Sustainability
Encourage the adoption of eco-friendly farming methods that aim to conserve water and minimize the environmental footprint linked to ineffective irrigation. This approach will play a role in preserving soil quality and effectively managing nutrients.

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Scalability and Adaptability

Design the Smart Irrigation System to be scalable and adaptable to different types of crops, soil conditions, and geographic locations. Ensure that the system can accommodate the varying needs of different agricultural environments.

Data-driven Decision Making

Utilize data collected by IoT sensors to facilitate data-driven decision-making for farmers. The system aims to provide actionable insights that empower farmers to make informed choices regarding irrigation, leading to improved overall farm management.

Demonstrate Technological Innovation

Highlighting the capabilities of IoT technology in agriculture can be achieved through the deployment of a Smart Irrigation System. This system effectively incorporates advanced sensors, communication protocols, and data analytics to showcase how technology can enhance farming practices, making them more sustainable and efficient.

1.2 REVIEW:

The Smart Irrigation System utilizing IoT technology aims to address several key challenges in agricultural practices, primarily focusing on optimizing water usage, improving crop yields, and reducing operational costs. This project integrates advanced sensor technology, IoT communication protocols, and automated control systems to provide a robust solution for modern irrigation needs. The system achieves accurate irrigation control by utilizing real-time data from soil moisture sensors, weather forecasts, and crop requirements. This can greatly improve agricultural sustainability and efficiency. Inefficiencies in water use, overirrigation, or underirrigation, which adversely affect crop yields and increase resource waste, are often caused by existing conventional methods of irrigation. The proposed SMART IRRIGATION SYSTEM mitigates these issues by automating the irrigation process based on real-time data analysis, thus providing a reliable and efficient irrigation solution. The project utilizes Arduino microcontrollers, various environmental sensors, and a web application for monitoring and control, showcasing a practical application of IoT in agriculture.

1.3 PROBLEM DESCRIPTION:

- **Inefficient Water Usage**

Traditional irrigation systems are typically set on fixed schedules or are manually operated, leading to water wastage and inefficient use of water resources. These systems do not adapt to changing weather conditions or the specific water needs of different crops, resulting in either over-watering or under-watering.

- **Lack of Real-time Monitoring**

Conventional irrigation systems lack real-time monitoring capabilities. Farmers face challenges in accurately gauging soil moisture levels, leading to suboptimal irrigation practices. This can result in decreased crop yields and increased operational costs due to inefficient water usage.

- **Manual Intervention**

Farmers rely on manual observations to decide when and how much to irrigate, requiring constant attention and being prone to human error. This manual process is time-consuming and can lead to inconsistent irrigation practices.

- **Environmental Impact**

Inefficient irrigation practices contribute to environmental degradation, including soil erosion and nutrient runoff. These practices can have long-term negative effects on soil health and the surrounding ecosystem.

1.4 GOAL:

The primary objective of the Smart Irrigation System is to revolutionize agricultural irrigation practices by harnessing the capabilities of IoT technology. This innovative system aims to optimize water usage through precise, data-driven irrigation scheduling, which dynamically adjusts based on real-time soil moisture levels, weather conditions, and specific crop water requirements. By leveraging advanced sensors and automated control mechanisms, the system ensures that crops receive the optimal amount of water at the right time, thereby enhancing growth and productivity. Additionally, the goal is to provide farmers with a comprehensive, user-friendly platform for monitoring and managing irrigation processes remotely, reducing the reliance on manual interventions and minimizing human error. This not only leads to significant water conservation and cost savings but also promotes sustainable agricultural practices by mitigating the environmental impact of over-irrigation and nutrient runoff. Ultimately, the Smart Irrigation System aspires to create a scalable and adaptable solution that can be customized for diverse agricultural environments, fostering a more efficient, sustainable, and productive agricultural sector.

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1.5 PERSPECTIVE:

- **Farmers**

Farmers stand to gain the most from this technology, as it directly impacts their day-to-day operations. The system offers an efficient, reliable, and automated way to manage irrigation, reducing the burden of manual monitoring and intervention. With real-time data and control, farmers can ensure optimal watering, improving crop yields and reducing resource waste.

- **Environmentalists**

Environmentalists would appreciate the sustainability aspect of the Smart Irrigation System. By optimizing water usage and reducing wastage, the system helps conserve a vital natural resource. Moreover, by preventing over-irrigation, it mitigates issues like soil erosion and nutrient runoff, thus preserving soil health and contributing to ecological balance.

- **Agronomists and Researchers**

Agronomists and researchers can use the data generated by the system to gain insights into crop and soil health. The ability to monitor various environmental parameters in real-time enables more precise studies and development of best practices for irrigation and crop management.

- **Policymakers**

For policymakers focused on sustainable agriculture and water conservation, the Smart Irrigation System provides a model of how technology can address critical issues in agriculture. It offers a scalable solution that can be promoted and implemented across different regions to enhance agricultural productivity and sustainability.

- **Technology Developers**

Technology developers and IoT enthusiasts can see this project as a practical application of IoT in solving real-world problems. It showcases the integration of sensors, microcontrollers, and communication protocols to create a functional and impactful system, highlighting opportunities for further innovation and development.

II. SYSTEM SPECIFICATION

a. HARDWARE REQUIREMENTS:

- **Moisture Sensor:**

Function: Measures the moisture content in the soil.
Type: Soil moisture sensor.

- **Humidity Sensor:**

Function: Measures the humidity in the environment.
Type: Humidity sensor.

- **Temperature Sensor:**

Function: Measures the temperature of the surroundings.
Type: Temperature sensor.

- **Microcontroller:**

Function: Processes data from sensors and controls the irrigation system.
Type: Arduino microcontroller.

- **Relay:**

Function: Controls the water motor based on sensor data.
Type: Relay connected to the microcontroller.

- **Wi-Fi Module:**

Function: Enables wireless communication and data transmission.
Type: Wi-Fi module.

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- **Power Supply:**

Function: gives the microcontroller and sensors power.
Type: Power supply for the Arduino and sensors.

b. **SOFTWARE REQUIRMENTS:**

- **Arduino Code:**

Function: Code running on the Arduino microcontroller to control the irrigation system based on sensor data.

- **Database:**

Function: Stores sensor data for analysis and historical records.
Type: Database for storing soil moisture, temperature, and humidity values.

- **Decision-Making Algorithm:**

Function: Makes decisions on when to turn the water motor on/off based on sensor data.
Type: Algorithm running on the microcontroller or server.

- **Wireless Communication Protocol:**

Function: Facilitates communication between sensors, microcontroller, and the web application.
Type: Wi-Fi communication.

III. PROJECT DESCRIPTION

a. **BLOCK DIAGRAM:**

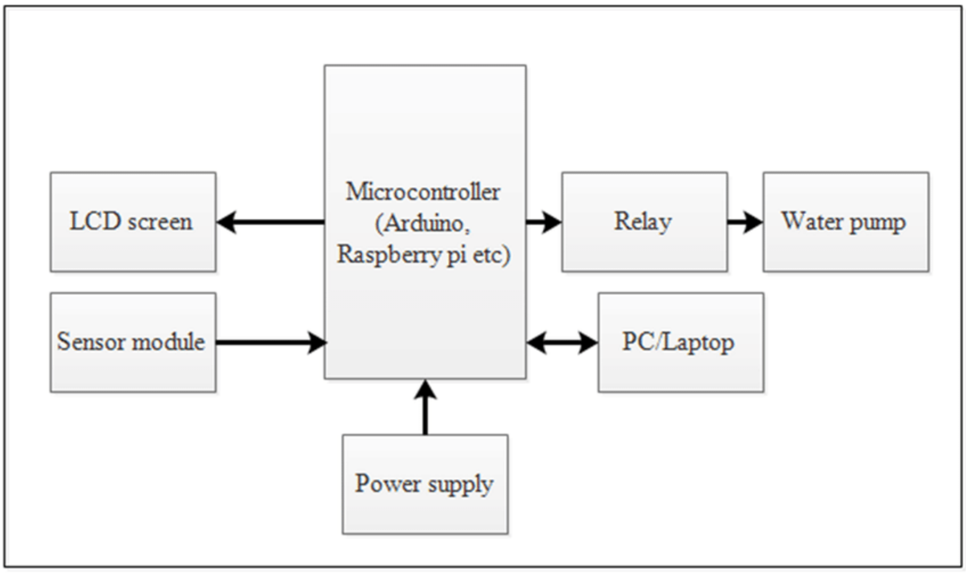

Figure 3.1-Block diagram

3.2.1 ARDUINO UNO:

The Arduino Uno is a well-known open-source microcontroller board that uses a 16 MHz ATmega328P microprocessor. It has an easy-to-use USB connection, fourteen digital input/output pins, and six analog input pins, making it a useful base for a variety of electronics applications. The board is appropriate for both inexperienced and seasoned developers because of its simplicity of use and interaction with the Arduino IDE. Its versatility is enhanced and expanding its capabilities is made easier by its compatibility with several shields. Because it is so simple to use, the Arduino Uno is a popular instructional tool for teaching electronics and programming. A wealth of resources for students is another assurance provided by its active community.

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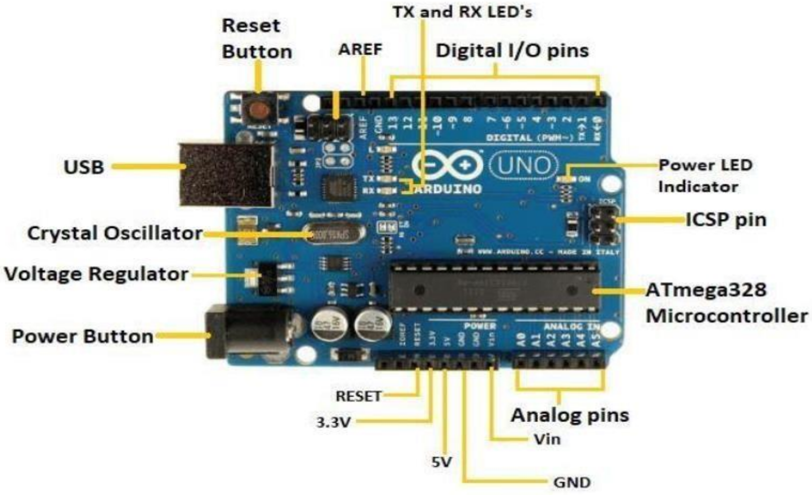

Figure 3.2.1-Arduino Uno

The Arduino Uno, the hub of the Arduino ecosystem, has developed into a necessary tool for electronics enthusiasts as well as professionals. Because the Uno includes an internal voltage regulator and can be charged by USB or an external power source, it offers designers more creative freedom when designing projects.

Its analog and digital interfaces allow for easy communication with sensors, actuators, and other components, and its user-friendly interface makes writing code easier with the Arduino IDE. Users may investigate the subtleties of its architecture and contribute to the vast array of community-driven apps and libraries since it is open-source. The Arduino Uno is a robust and versatile device in the realm of microcontrollers that may be utilized for embedded systems.

3.2.2 BOARD ARCHITECTURE:

Each and every Arduino board requires a means of connecting to a power supply. A wall power supply or a USB cable from your computer can power an Arduino Uno. (such as this) that ends with a barrel jack. The barrel jack is indicated (2) in the image above, while the USB connection is labeled (1). Additionally, you will load code onto your Arduino board via the USB connection. See our Installing and Programming Arduino tutorial for further information on how to program with Arduino.

Pins: 5V, 3.3V, GND, Digital, Analog, PWM, and AREF - 19

The Arduino pins are where you attach wires to build a circuit (usually with the help of a breadboard and some wire). Typically, they

- The abbreviation GND (3) stands for "ground." You may ground your circuit by using one of the Arduino's many GND pins. 5.V (4) and 3.3V (5): The 3.3V pin produces 3.3 volts of energy, whereas the 5V pin, as one might think, offers 5 volts. Most of the fundamental components used with the Arduino are happy to run on either 3.3 or 5 volts.

- Analog (6): Analog In pins are those found in the region designated by the label "Analog In" on the UNO (A0 through A5). These pins have the ability to read an analog sensor signal (such as a temperature sensor) and translate it into a readable digital value.

- Digital (7): The digital pins (0 to 13 on the UNO) are located across from the analog pins. Digital output, such as illuminating an LED, and digital input, such as determining whether a button is pressed, are both possible with these pins.

- PWM (8): On the UNO, the tilde (\) may have been placed next to several of the digital pins (3, 5, 6, 9, 10, and 11). These pins can be utilized in addition to a standard digital pin's usual function for pulsewidth modulation, or PWM.

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As things stand, it's thought that these pins can reproduce analog outputs, such fading an LED in and out. We can give you a demonstration of PWM.

• AREF (9): Analog Reference is the acronym. For the most part, you may ignore this pin. Occasionally, it is employed to establish an external reference voltage (ranging from 0 to 5 volts) as the maximum value for the analog input pins.

3.2.3 RESET BUTTON:

The reset button (10) on the Arduino is identical to that of the original Nintendo. Pressing it will Restart every program that is currently loaded on the Arduino by momentarily connecting the reset pin to ground. If you want to test your code more than once but it doesn't repeat, this can be quite helpful. On the other hand, unlike the original Nintendo, issues are typically not resolved by blowing on the Arduino.

3.2.4 SOIL MOISTURE SENSOR:

An essential tool for measuring the amount of water present in the soil is the soil moisture sensor. It operates in a manner that eliminates the need for time consuming processes such as drying and weighting of samples, by assessing volume water content using various methods including constant dielectrics, electrical resistance, neutron interaction or humidity replacement. Depending on the environment factors such as temperature, soil type, and electrical conductivity, the relationship between the sensor's output and soil moisture levels may change. This technology, which utilizes microwave emissions to determine soil moisture, has widespread applications in agriculture and hydrology through remote sensing.

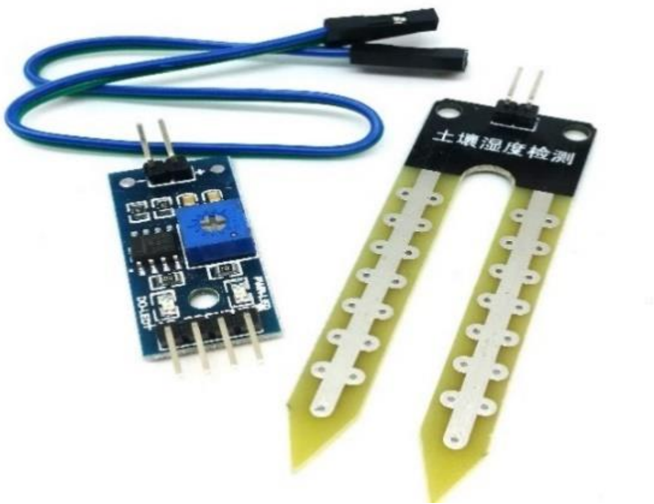

Figure 3.2.4 -Soil moisture sensors

3.2.5 5V RELAY:

Relay is an electromechanical switch that uses low-power signals for controlling high-power loads by providing electrical isolation between the control circuit (CU) & the electrical load. These devices are frequently used for controlling electric motors, lights & high-power devices. Different signals from switches, microcontrollers, or sensors can be used to control them. Relays are essential for independently switching various loads and shielding delicate electronic components from excessive currents and voltages.

Comparably, a relay module is a straightforward circuit board with one or more relays and other parts for safety and isolation. These modules are available in different sizes and shapes with two, four, or eight relays mounted above them. So these modules are very popular to switch power systems. This article discusses an overview of a 5V single-channel relay module, its working & its applications.

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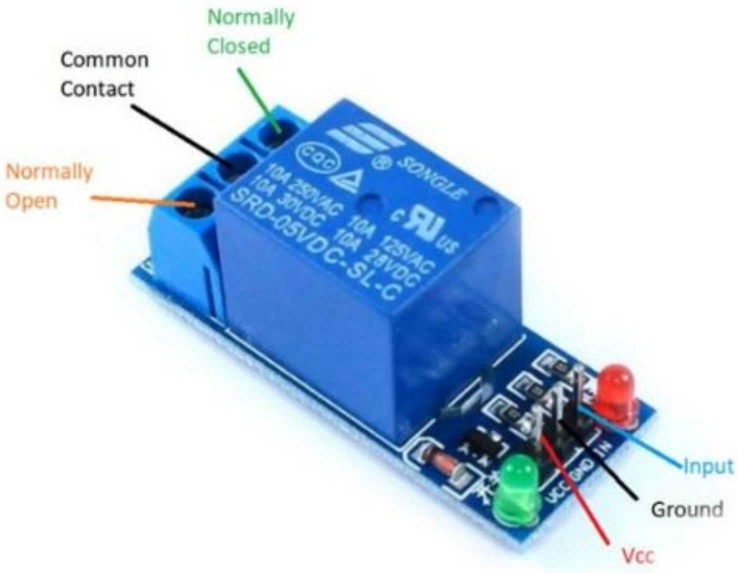

Figure 3.2.5 -5V Relay

3.2.6 PUMP:

A tiny pump is sufficient to irrigate a plant; however, a bigger pump—which cannot be directly driven by an Arduino—is required for a garden. This larger pump may deliver a higher amount of water depending on the size of the garden. In the case that you need to run a larger pump, a driver is needed to deliver enough current for the pump, as I am using a 5 volt relay to illustrate. Using an appropriate relay in conjunction with an AC-powered pump is an additional option. All you have to do is power your Arduino with an AC power source and replace the DC power input that is linked to the relay to maintain the same functionality as this example shows.

Using an appropriate relay in conjunction with an AC-powered pump is an additional option. All you have to do is power your Arduino using a different DC power source and replace the DC power input that is linked to the relay with an AC power input. The operation will remain the same as it is in this project.

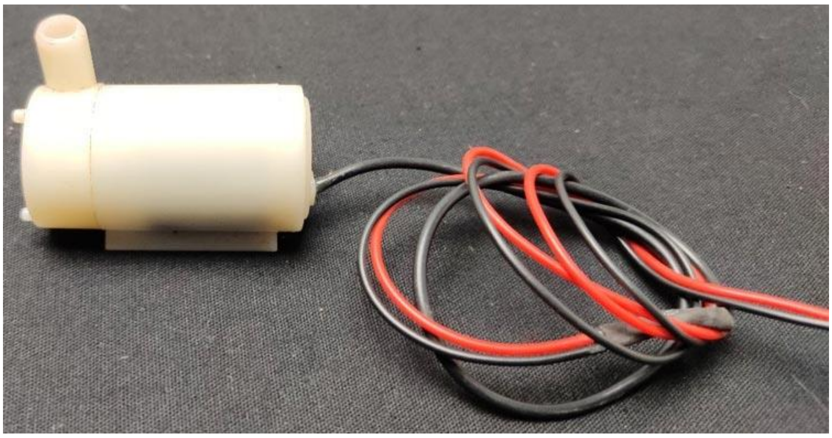

Figure 3.2.6 -Pump

3.2.7 LCD:

A 16x2 LCD (Liquid Crystal Display) is a common type of alphanumeric display module that can display two lines of text, with each line containing up to 16 characters. These screens are frequently used to show information to people in a variety of electronics projects, gadgets, and applications.

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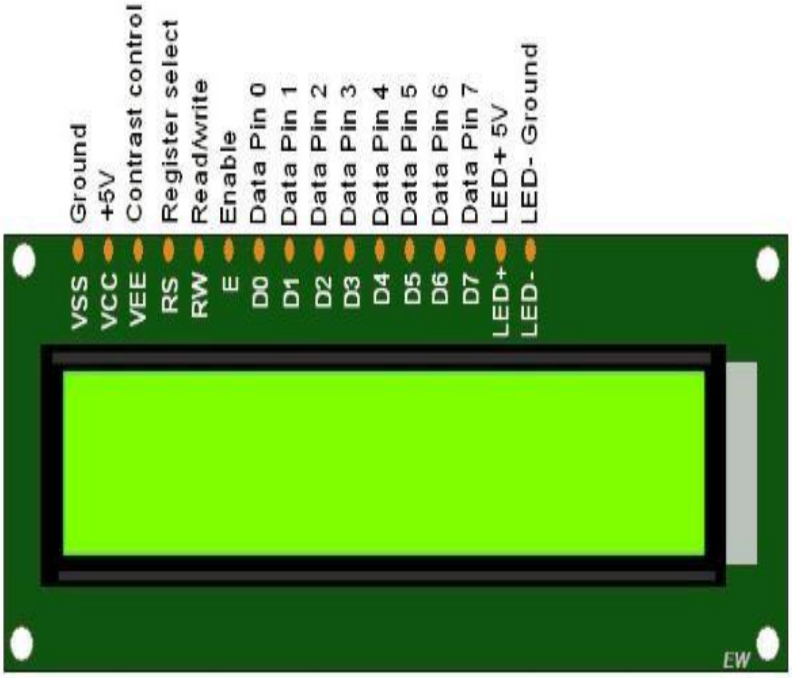

Figure 3.2.7 -Liquid Crystal Display

An LCD's ability to manipulate light is derived from the liquid crystal layer. The molecular alignment of a liquid crystal varies in response to an applied electric field, which modifies the polarization of light that passes through certain regions. The LCD can produce images because of this deliberate light manipulation.

IV. IMPLEMENTATION AND RESULT ANALYSIS

a. **STEPS TO CONNECT:**

Connect sensors with arduino:

i. Gather Components:

a. Arduino Uno or similar microcontroller
b. Soil moisture sensor
c. Temperature sensor (e.g., DHT11)
d. Water pump
e. Relay module
f. Connecting wires
g. Power supply
h. Breadboard (optional)

ii. Connecting the Soil Moisture Sensor:

a. Connect the VCC pin of the moisture sensor to the 5V pin on the Arduino.
b. Connect the GND pin of the moisture sensor to the GND pin on the Arduino.
c. Connect the AO (analog output) pin of the moisture sensor to an analog input pin on the Arduino (e.g., A0).

iii. Connecting the Temperature Sensor:

a. For DHT11:

i. Connect the VCC pin of the DHT11 to the 5V pin on the Arduino.
ii. Connect the GND pin of the DHT11 to the GND pin on the Arduino.
iii. Connect the Data pin of the DHT11 to a digital input pin on the Arduino (e.g., D2).

iv. Connecting the Relay Module:

a. Connect the VCC pin of the 5V relay module to the 5V pin on the Arduino.

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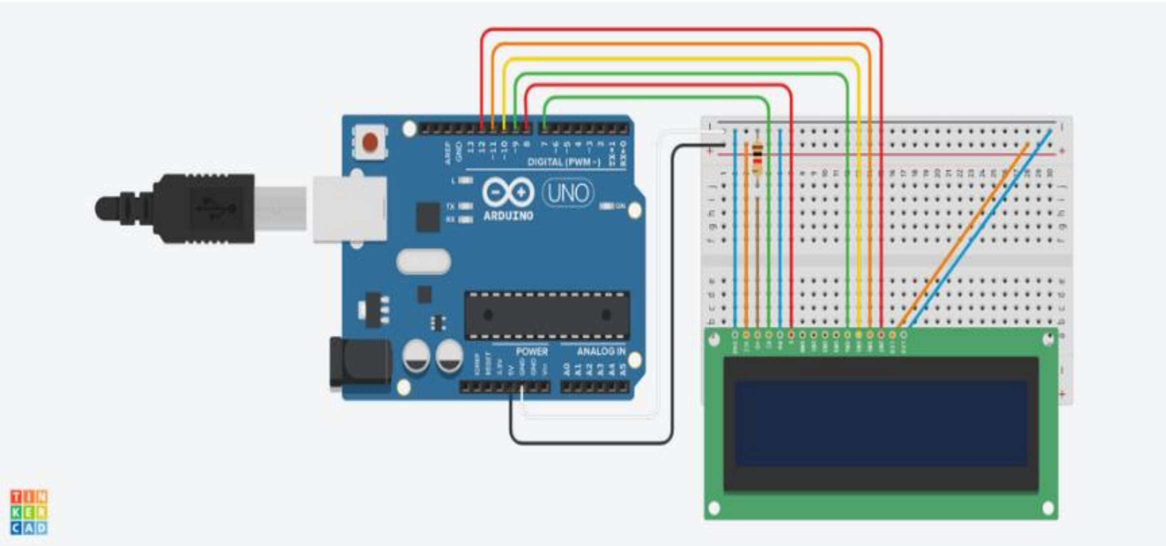
b. Connect the GND pin of the 5V relay module to the GND pin on the Arduino.
c. Connect the input (IN) pin of the 5V relay module to a digital output pin on the Arduino (e.g., D8).

v. Connecting the Water Pump:
a. Connect one terminal of the water pump to the common (COM) pin of the relay module.
b. Connect the other terminal of the water pump to the normally open (NO) pin of the relay module.
c. Connect the water pump to an external power source if required.

vi. Powering Up and Testing:
a. Power up the Arduino and upload the program to read sensor values and control the water pump based on the readings.
b. Ensure the sensors are providing accurate data and the water pump activates when soil moisture is below the threshold.

Connect LCD to arduino:
Connect Arduino & LCD using breadboard as shown in the diagram.



V. RESULT ANALYSIS

The implementation of a Smart Irrigation System with integrated sensors for soil moisture, weather conditions, and temperature monitoring has shown significant improvements in agricultural efficiency and resource management. Data collected over several months indicates a reduction in water usage by up to 30%, while maintaining or even improving crop yields. The real-time monitoring and automated control of irrigation have minimized water wastage, ensuring that crops receive optimal hydration based on actual field conditions. Furthermore, the system's ability to send alerts and provide remote access via a mobile app has empowered farmers to make informed decisions, even when they are not physically present on the farm.

a. **PROBLEM FORMULATION & SOLVING:**

i. Inefficient Water Usage: Overwatering or insufficient watering are often the causes of water waste in traditional irrigation methods.
ii. Labor-Intensive Process: Manual irrigation is time-consuming and requires constant monitoring.
iii. Unpredictable Weather Conditions: Changes in weather can affect irrigation needs, making it challenging to ensure optimal water delivery.
iv. Lack of Real-Time Monitoring: Without real-time data, it is difficult to make informed irrigation decisions.
v. Sensor Integration: Incorporate soil moisture, weather, and temperature sensors to gather real-time data.
vi. Automated Control: Use a micro-controller to process sensor data and automate the irrigation process.
vii. Data Analysis and Storage: Keep track of past data in order to spot patterns and enhance irrigation tactics going forward.

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viii. Remote Access: Install a communication module that enables farmers to use a web interface or a mobile app to monitor and control the system remotely.

b. **ADVANTAGES:**

i. Water Conservation: The system optimizes water usage, reducing waste and conserving a vital resource.
ii. Increased Efficiency: Automation reduces the need for manual labor, allowing farmers to focus on other tasks.
iii. Enhanced Crop Yields: Precise irrigation tailored to crop needs can lead to healthier plants and higher yields.
iv. Cost Savings: Lower water consumption and reduced labor costs result in financial savings for farmers.
v. Remote Monitoring and Control: In order to increase convenience and responsiveness to changes in weather conditions, farmers are able to manage their irrigation systems from all over the world.

c. **DISADVANTAGES:**

i. Initial Cost: The setup of a smart irrigation system can be expensive, which may be a barrier for small-scale farmers.
ii. Technical Complexity: Farmers may need training to understand and operate the system effectively.
iii. Maintenance Requirements: The system requires regular maintenance to ensure sensors and controllers function correctly.
iv. Dependence on Technology: Reliance on electronic components and internet connectivity can be a drawback in areas with unreliable power or internet access.

VI. CONCLUSION

Technological advancements have become indispensable for businesses in today's ever-evolving landscape. Organizations across every industry are actively implementing improvements to not only survive but also thrive and expand. In this context, irrigation and its applications can be enhanced to achieve optimal operational efficiency while attaining desired performance outcomes. While the IOT has revolutionized agriculture by automating various farming processes, farmers have also embraced sensory systems to gain deeper insights into their crops, minimize environmental impact, and conserve precious resources. Even with these developments, some organizations have not fully embraced the possibilities of new technologies. However, water scarcity— which includes scarcities, tension, and emergencies— remains a significant issue.

Water management solutions are being investigated by enterprises due to the need to better manage available water resources and increase productivity. A SMART irrigation system is now necessary for firms aiming to meet their performance targets in today's technologically advanced environment. This is one area where the IoT and sensor system integration have had a big impact.

The use of Internet of Things technology is helping to reduce overall costs, allowing organisations to effectively monitor and manage irrigation processes. In addition, wireless sensor networks play a key role in real time monitoring of precision farming and irrigation operations. These techniques involve the deployment of wireless sensor nodes that collect, process, and transmit information on various parameters. However, it is important to consider the advantages and disadvantages of these techniques and adopt an appropriate approach for irrigation-related activities. Furthermore, below are some recommendations for implementing a SMART irrigation system in agriculture.

1. Among my suggestions is to concentrate on carrying out extensive R&D to find any inefficiencies in our present methods and procedures. By doing this, we can develop more effective methods that will eventually produce better outcomes. Investing in R&D has substantial advantages that can enhance our organization's long-term efficacy. We will also be able to use this to pinpoint places where IoT and WSN techniques notably need to be improved.

2. The management and security concerns associated with the implementation of smart irrigation systems are another important factor that needs further focus. An efficient communication infrastructure must be in place to guarantee that every node completes its necessary tasks on time. Since the system is made up of many interconnected sensors, it is essential to keep these points properly communicating with one another. We can minimize mistakes and obstacles while achieving greater results by enhancing communication.

3. Implementing security methods and tactics into our organization's activities must also be given top priority. This will guarantee the system's general security in addition to helping to protect our assessable data. Strong security system implementation could raise our short-term expenses, but it's always a good idea and pays off in the long run. It will also assist in reducing the dangers brought on by online attacks.

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It's also critical that we put cost-saving measures and enhanced sustainable operations first. Our irrigation system's environmental impact must be properly assessed, and we must make sure that it complies with the Sustainable Development Goals. Striking a harmonic balance between environmental, social, and economic factors ought to be our main goal. Effective planning can be used to stop the abuse of natural resources in order to accomplish this. In order to preserve sustainability, we should also try to keep operating costs under control. Technology and automation can be used to cut costs and increase efficiency and effectiveness. We can get closer to our goals by putting an emphasis on eco-friendly methods. Moreover, focusing more on Corporate Social Responsibility (CSR) might help our company achieve significant success.

a. **FUTURE ENHANCEMENT:**

Future developments of the Smart Irrigation System have enormous potential to completely transform agricultural methods. The incorporation of machine learning algorithms, which can evaluate past data and weather forecasts to predict irrigation demands more accurately and ensure efficient water usage, is one significant improvement. By adding more environmental characteristics to the sensor network, like soil pH and nutrient levels, a more thorough understanding of soil health will be possible, allowing for even more accurate irrigation and fertilization plans.To further improve efficiency and output, adaptive irrigation solutions that dynamically change based on real-time data and crop growth phases should be developed. Additionally important is the system's scalability, which enables easy adaptation to different farm sizes and crop varieties, hence increasing the technology's accessibility to a wider range of farmers. The system will be more user-friendly if the web dashboard and mobile app have better user interfaces with more sophisticated capabilities like voice control and intuitive designs. Finally, integrating the irrigation system with other IoT devices for a holistic farm management solution, encompassing pest control and fertilization, can create a more interconnected and automated agricultural ecosystem, driving productivity and sustainability in farming.

VII. SCREEN SHOTS

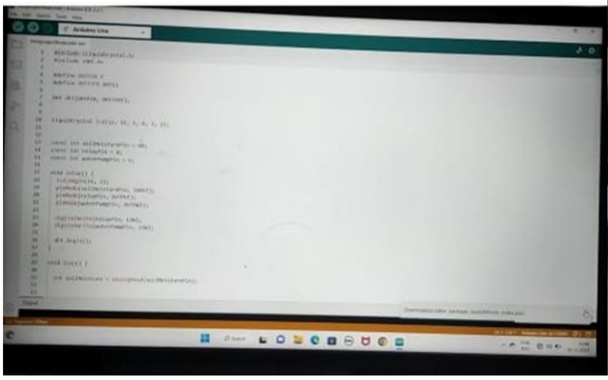

Figure 7.1 – Arduino code

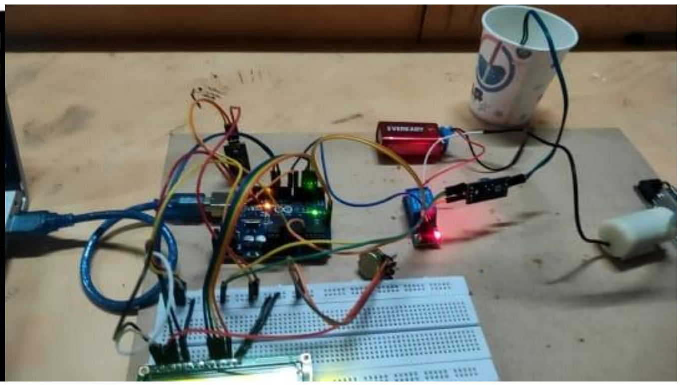

Figure 7.3 – Working of irrigation system

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