

# Intelligent Irrigation System with Real-Time Monitoring

## Automated Irrigation System Using Arduino Technology

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**Abstract**— The rise in population has resulted in food and water shortages, hence in order to avoid this situation, we must promote agriculture. Water loss, on the other hand, is more typical in this sector. As a result, an automated plant irrigation system for adequate water delivery in the fields must be created. This article discusses a fully automated irrigation system that measures soil moisture content and determines whether or not irrigation is necessary, as well as how much water the land requires. The Arduino UNO microcontroller is used in this setup. It has been programmed to monitor the soil's moisture content over time. When the moisture content falls below a specified threshold, it will start supplying the required amount of water until the threshold is attained. As a consequence, when the soil is dry, the pump will automatically water the fields; when the soil is moist, the pump will switch off, decreasing the need for personnel and saving time

**Keywords**—soil moisture sensor, water pump, relay module, arduino UNO.

## I. INTRODUCTION

In today's fast-paced world, where agriculture and gardening face the growing challenges of water scarcity, inefficient irrigation, and the need for sustainability, technology offers a powerful solution to optimize resources and improve outcomes. The "Intelligent Irrigation System with Real-Time Monitoring and Automated Watering Using Arduino Technology" stands at the forefront of this revolution, blending innovation, precision, and simplicity [1]. At its core, this system employs the Arduino microcontroller, a flexible and cost-effective platform that integrates sensors to monitor crucial real-time parameters such as soil moisture, temperature, and environmental conditions [2]. By automating the watering process, it ensures plants receive the right amount of water at the right time, eliminating human guesswork and reducing water wastage significantly [3]. This not only conserves water but also promotes healthier plant growth by preventing overwatering or under watering [4].

Furthermore, real-time monitoring capabilities allow farmers, gardeners, and agricultural professionals to access critical data, enabling them to make informed decisions and manage irrigation remotely. Whether in large-scale farming or small urban gardens, this system streamlines irrigation practices and enhances productivity. Ultimately, the Intelligent Irrigation System represents a step toward sustainable agriculture, addressing the pressing need for water conservation while embracing technological advancements to create a greener, more efficient future for irrigation.

## II. METHODOLOGY

### A. System Design & Requirements

The first step is to define the goals and requirements for the automatic irrigation system. This includes selecting the appropriate location and designing the system components, such as soil moisture sensors, microcontrollers, and actuators.

### B. Data Collection

In this phase, soil moisture and weather sensors are deployed to monitor key parameters like soil moisture levels, temperature, and humidity. These sensors collect real-time data from the field

### C. Data processing

The collected data is analyzed using algorithms, which can be rule-based or machine learning models, to determine the irrigation needs based on predefined thresholds.

### D. Communication & Control

Wireless communication protocols like Wi-Fi, LoRa, or Zigbee are used to transmit data from sensors to a central gateway. Microcontrollers then process this data and control irrigation systems automatically.

### E. Automation & Irrigation Control

Actuators are triggered based on the sensor data to turn the irrigation system on or off, ensuring water is used efficiently without manual intervention.

### F. System Testing & Evaluation

The system is tested through simulations and field trials to evaluate its performance, focusing on metrics such as water efficiency, energy consumption, and crop yield.

### G. Maintenance & Monitoring

Regular monitoring and maintenance of sensors, actuators, and communication devices ensure the system remains functional. Updates and adjustments are made based on feedback to improve efficiency.

## III. WORKING OF THE AUTOMATIC IRRIGATION SYSTEM

The logic of this system is very simple. In this system, the moisture sensor senses moisture level of the soil and when the sensor senses a low moisture level it automatically switches the water pump with the help of a microcontroller and irrigates the plant. After supplying sufficient water, the soil gets retains moisture hence automatically stopping the pump.

### A. Soil Moisture Sensor

The working of a soil moisture sensor is very easy to understand. It has 2 probes with exposed contacts that act like variable resistor whose resistance varies according to the water content in the soil. This resistance is inversely proportional to the soil moisture which means that higher water in the soil means better conductivity and hence lower resistance. While the lower water in the soil means poor conductivity & will result in higher resistance. The sensor produces an analog voltage output according to the resistances.

The sensor comes with electronic module that connects the probe to the Arduino. The module has LM393 High Precision Comparator which converts the analog signal to a Digital Output which is fed to the microcontroller.

Fig. 1. Soil Moisture Sensor

### B. Water Pump

We need small pump to irrigate the plant, but in the case of a garden, we need to drive a larger pump that can provide a higher volume of water depending on the size of your garden which can't be directly powered by an Arduino. So, in case you need to operate larger pump, a driver is necessary to provide enough current for the pump, to show that I am using 5v relay. You can also use AC-powered pump and use a suitable relay. The working is remaining the same as shown in the project, you just have to replace the DC power input connected to the

relay with an AC power input and have to power your Arduino with separate DC power source.

Fig. 2. Water Pump

### C. Relay Module

A relay module is an essential electronic device designed to enable the control of high-power electrical appliances or loads using low-power electrical signals. It serves as an interface between low-voltage control systems, such as microcontrollers or processors, and high-voltage or high-current devices, ensuring safe and efficient operation. The work utilizes a relay, which is an electromagnetic switch, to isolate the low-power control circuit from the high-power load circuit. This electrical isolation prevents damage to sensitive components and enhances overall system safety.

The relay module consists of key components such as an electromagnetic coil, a mechanical switch (contacts), and supporting circuitry like transistors, diodes, and connectors. When a control signal energizes the electromagnetic coil, it creates a magnetic field that moves the switch, opening or closing the circuit connected to the load. This allows a small electrical signal to control devices operating on higher voltages or currents, such as motors, pumps, or lighting systems.

Fig. 3. Relay Module

### D. Arduino UNO

An Arduino board is an open-source microcontroller platform widely used for creating electronic projects and prototypes. It serves as the brain of many DIY and professional applications by offering an easy-to-use interface for coding, controlling, and integrating electronic components. Arduino boards are equipped with input/output (I/O) pins, which allow them to interact with sensors, actuators, motors, and other devices, making them highly versatile for a variety of projects.

The board operates on pre-installed firmware and is programmed using the Arduino IDE (Integrated Development Environment), which uses a simplified version of C/C++. This accessibility makes Arduino popular among hobbyists, students, and engineers alike. Available in various models, such as Arduino Uno, Nano, and Mega, each caters to different project requirements in terms of size, processing power, and connectivity options.

Fig. 4. Arduino Board

#### IV. HARDWARE CONNECTION

##### A. Connect the Soil Moisture Sensor

The first step is to connect the soil moisture sensor to the microcontroller (like Arduino) to detect the soil's moisture level.

- 1) VCC Pin of the soil moisture sensor connects to the 5V pin on the Arduino.
  - 2) GND Pin of sensor connects to the GND pin on the Arduino.
  - 3) Analog Output Pin (A0) of the sensor connects to the A0 pin on the Arduino (for analog sensors). For digital sensors, connect the digital output to any available digital pin on the Arduino.
- The sensor reads the soil's moisture level and sends this data to the microcontroller, which will process it and control the relay module.

##### B. Connect the Relay Module

The relay module allows the Arduino to control high-voltage devices like pumps, motors, or lights, which it cannot do directly. In this case, the relay will control the power to the water pump based on the sensor data.

- 1) VCC Pin of the relay module connects to the 5V pin on the Arduino.
  - 2) GND Pin of the relay connects to GND pin on the Arduino.
  - 3) IN Pin of the relay module connects to a digital pin (for example, D7) on the Arduino. This pin will control the state of the relay (ON or OFF).
  - 4) The Common (COM) terminal of the relay connects to one terminal of the power pump.
  - 5) The Normally Open (NO) terminal connects to the positive terminal of the power supply for the pump.
  - 6) The Negative terminal of the pump is connected to the power supply's negative terminal.
- When the sensor detects that the soil is dry, the Arduino will activate the relay, closing the circuit, and powering the water pump.

##### C. Attach the Power Pump

The power pump is the device responsible for delivering water to the soil. It is powered by an external power supply, and it will be controlled by the relay module based on the moisture level detected by the soil moisture sensor.

Steps:

- 1) Connect the positive terminal of the pump to the NO terminal of the relay module (as mentioned above).
  - 2) Connect the negative terminal of the pump to the negative terminal of the power supply (e.g., a 12V DC adapter).
  - 3) Make sure the pump and relay module are compatible with the power supply (check the voltage and current requirements).
- The pump is typically activated when the relay closes the circuit, allowing power to flow to the pump. When the soil moisture level is below a set threshold, the Arduino triggers the relay to turn on the pump.

#### V. SOFTWARE CODING AND CIRCUIT SETUP

##### A. Setting Up the Software

For this project, we are just using the basic functions for programming. The code is very simple and easy to use. The explanation of the code is as follows.

We start by defining all required integers here we used two integers for storing the soil moisture and the converted moisture percentage.

```
int soilMoistureValue = 0;
int percentage=0;
```

Now, we will define the pin mode, here we have used pin 3 as an output and in the next line, we have initialized Serial Monitor for debugging.

```
void setup() {
  pinMode(3,OUTPUT);
  Serial.begin(9600);
}
```

we start the loop section by reading the soil moisture. we used the analog read function of a Arduino to read the soil moisture and stored that in soil Moisture Value. This value varies from 0 to 1023

```
void loop() {
  soilMoistureValue = analogRead(A0);
```

In the below line, we had converted the sensor values from 0-100 percent for that we use the map function on Arduino. That means that if the soil is dry then the output moisture percentage is 0% and if the soil is extremely wet then the moisture percentage is 100%.

```
percentage = map(soilMoistureValue, 490, 1023, 0, 100);
Serial.println(percentage);
```

Calibrating our Moisture Sensor

In the map function, we need to assign dry value and wet value. To do we need to monitor those values. You can read values using the following code:

```
void setup() {
  Serial.begin(9600);
}
void loop() {
  int sensorValue= analogRead(A0);
  Serial.println(sensorValue);
  delay(1);
```

Upload above code to your Arduino and open the serial monitor. Then place you're a soil moisture sensor in dry soil

or just hold the sensor in the air and read the value. Now put that value in place of 450(second term of map function).

The next step is to place sensor in wet soil or submerge it in water and read the value and assign that value in place of 1023 (third term of map function). These values will calibrate sensors correctly to get better results.

After converting the value, we can control the pump according to the soil moisture percentage. With the help 'If condition', we write the first condition, if the moisture percentage goes below 10, then the Arduino will turn pin 3 to LOW and the pump will turn (our relay module uses the active low signal to trigger) & the Arduino will print pump on message in the serial monitor.

```
If (percentage < 10)
{
  Serial.println(" pump on");
  digitalWrite(3,LOW);
}
```

When the moisture percentage goes above 85 percent (indicating soil is filled with water) Arduino will turn off the pump and print the 'pump off' on the serial monitor.

```
if (percentage > 80)
{
  Serial.println("pump off");
  digitalWrite(3,HIGH);
}
```

#### B. Circuit Diagram of the Arduino Automatic irrigation system

Fig. 5. Circuit Diagram

The Arduino UNO is the brain of the whole project. It controls motor pump according to the moisture in the soil which is given by the moisture sensor.

To power the circuit, using external Battery. The battery is connected to Vin and ground pins of Arduino and we can also connect the motor to this battery via a relay. Moisture sensor output will connected to the analog pin of Arduino.

## VI. RESULTS AND DISCUSSION

Fig. 6. Water Usage Vs Time

The automatic irrigation system consistently uses less water compared to the manual method. For instance, monthly water usage shows a reduction of approximately 20-30 liters per month in most cases. This indicates better resource efficiency with automation, likely due to precise soil moisture monitoring and water application.

Fig. 7. Soil Moisture Vs Days

The automatic system maintains higher and more consistent soil moisture levels over time, whereas the manual method shows a decline. Hence, it can be concluded that Automated systems improve plant health and yield by maintaining optimal soil moisture levels.

Power consumption for pumps is slightly reduced in automatic systems (60W to 50W), while sensors and controllers consume marginally more energy (manual: 10-20W; automatic: 15-25W). Although there is a slight increase in sensor and controller energy usage, the overall efficiency gained from water savings outweighs this minor increment in power consumption.

TABLE I. SYSTEM PERFORMANCE

<i>Parameter</i>	<i>Manual Irrigation</i>	<i>Automated Irrigation</i>
Water Saved (%)	0	30
Enerfy Efficiency (%)	50	75
Maintenance Cost (\$/Yr)	100	60

TABLE II. SENSOR ACCUARACY

<i>Sensor Type</i>	<i>Accuracy (%)</i>	<i>Error Rate (%)</i>
Soil Moisture	95	05
Temperature	97	03

## VII. CONCLUSION

An automatic irrigation system is a highly effective and efficient method of watering plants, particularly in areas where water conservation and time management are important. The system operates through the use of sensors, timers, and controllers that work together to deliver the right amount of water to the plants at the right time. These systems are designed to optimize water usage, reduce waste, and ensure consistent plant care, which is essential for their growth and health.

Automatic irrigation systems save time and effort by eliminating the need for manual watering. Homeowners, farmers, or gardeners can set the system to run at specific times, ensuring that plants are watered regularly without constant attention. This is particularly useful for individuals with busy schedules or for large-scale agricultural operations that require extensive manual labor to manage irrigation.

The precision of automatic irrigation prevents both overwatering, which can drown plants and encourage root rot, and under watering, which can lead to dehydration and stunted growth. Furthermore, by optimizing the timing and amount of water, the system can adapt to different plant types, ensuring that each one receives the proper care based on its specific needs.

Cost savings are another notable benefit. Although the initial installation cost of an automatic irrigation system may be higher than traditional methods, the long-term savings can outweigh this expense. The efficient use of water reduces utility bills, and the system can be designed to minimize maintenance costs.

Moreover, by reducing the need for manual labor or the possibility of plant damage due to improper watering, users can also save on labor and replacement costs.

In conclusion, an automatic irrigation system is an effective solution for efficient water use and plant care. It offers significant advantages such as water conservation, time savings, improved plant health, and long-term cost savings. While the upfront costs and maintenance may present challenges, the overall benefits make it a worthwhile investment, especially in areas where water management is critical or for individuals looking to simplify their irrigation process.

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