Smart Automatic Garden Watering System Using Soil Moisture Sensors

Amarappa Pagi[1], Srusti Madiwalar[2], Supriya Ghodake[3]
[1]*AssistantProfessor, Dept of ECE, Smt. Kamala and Sri. Venkappa M Agadi Collge of Engineering and Technology,* Lakshmeshwar
amarappa.ece@agadiengcollege.com
[2]*UG Student, Dept of ECE, Smt. Kamala and Sri. Venkappa M Agadi Collge of Engineering and Technology,* Lakshmeshwar
srustimadiwalar6@gmail.com
[3]*UG Student, Dept of ECE, Smt. Kamala and Sri. Venkappa M Agadi Collge of Engineering and Technology,* Lakshmeshwar
supriyaghodake517@gmail.com

***Abstract*— This project presents a decorative automatic garden watering system implemented without a microcontroller, using only discrete electronic components on a breadboard. The system detects soil moisture using conductive probes and automatically activates a water pump when the soil becomes dry through a transistor-based switching circuit. Once sufficient moisture is restored, the pump is turned off, preventing overwatering and conserving water. LED indicators provide visual status of soil conditions, adding a decorative feature. The circuit uses simple components such as transistors, resistors, relays, and diodes, making the system low-cost, energy-efficient, and suitable for small home gardens and educational applications. The design demonstrates how analog electronics can effectively perform automation tasks without complex programming or digital controllers.**

Keywords*— Automatic Garden Watering System, Soil Moisture Sensor, Transistor Switching Circuit, Breadboard Implementation, Analog Electronics, Water Pump Automation, LED Indicators.

I. INTRODUCTION

In recent years, sustainability and eco-friendly living have become increasingly important. As a result, home gardening has gained popularity as a meaningful hobby. Many individuals prefer growing their own plants, flowers, vegetables, and herbs to reconnect with nature, improve indoor and outdoor environments, and contribute to a greener lifestyle. Home gardens not only enhance the aesthetic appeal of living spaces but also promote mental relaxation, reduce stress, and encourage healthier habits. However, maintaining a garden requires proper and timely watering, which is essential for healthy plant growth. Irregular watering—either excessive or insufficient—can negatively affect plant health and productivity. This challenge becomes more significant for individuals with busy schedules or those who travel frequently.

Automatic watering systems were developed to address this issue by ensuring that plants receive water whenever required. These systems typically monitor soil moisture levels and activate a water supply accordingly. However, many existing automatic watering systems rely heavily on microcontrollers such as Arduino or Raspberry Pi. Such systems often require programming knowledge, complex wiring, digital sensors, and sometimes mobile applications for monitoring and control. For beginners, students, or hobbyists with limited technical background, these systems may be difficult to design, implement, and maintain.

To overcome these limitations, this project proposes a decorative automatic garden watering system that operates without the use of a microcontroller. The system is implemented using simple analog electronic components such as resistors, transistors, relays, diodes, LEDs, and a basic soil moisture sensing probe. All connections are made on a breadboard or printed circuit board (PCB), making the design simple, cost-effective, and easy to understand. By eliminating programming requirements, the project focuses on fundamental electronic principles, demonstrating how basic components interact to create an automated system.

The system operates by detecting soil moisture through two metallic probes inserted into the soil. Moist soil provides lower resistance and allows current to flow easily, whereas dry soil increases resistance and restricts current flow.

II. PROBLEM STATEMENT

In today's busy lifestyle, many people forget or do not have enough time to water their garden plants regularly, which leads to dry soil and unhealthy plant growth. Manual watering can also result in uneven water distribution and unnecessary water wastage. Therefore, there is a need for a simple, low-cost, and automatic watering system that can operate without the use of microcontrollers such as Arduino. The system should be easy to construct using basic electronic components on a breadboard. Additionally, to improve usability and visual appeal, the system should include decorative features such as LED indicators to display the system status while enhancing the garden's appearance.

III. OBJECTIVES

The main objectives of this project are:

- To design and build an automatic garden watering system using manual wiring on a breadboard without any microcontroller.
- To select and collect all the necessary electronic components required for the system.
- To study and understand the electrical characteristics and working principles of each component used in the circuit.
- To test individual components to ensure proper functionality before system integration.
- To assemble and connect all components carefully on the breadboard to form the complete circuit.

- To simulate sensor signals manually and observe the system response under different soil moisture conditions.
- To evaluate the overall performance of the system and ensure reliable operation.

IV. LITERATURE SURVEY

Several researchers have developed automatic plant watering systems using microcontrollers and Internet of Things (IoT) technologies to improve irrigation efficiency and reduce human effort.

[1] The **Automatic Plant Watering System using Arduino** is designed to reduce manual effort in watering plants. The system uses a **soil moisture sensor** to continuously monitor the moisture level of the soil. When the moisture level falls below a predefined threshold, the **microcontroller (ATmega328)** activates a water pump to supply water automatically. Once the required moisture level is reached, the pump turns off, ensuring efficient water management and proper plant care.

[2] An **IoT-based automatic irrigation system** has been developed to assist farmers by reducing the need for manual watering. The system uses a **soil moisture sensor** to monitor soil conditions and automatically control a water pump through a **NodeMCU microcontroller**. Additional sensors such as **temperature, humidity, rainfall, and light sensors** are used to monitor environmental conditions, and the data is transmitted to a **Blynk IoT server** for remote monitoring through a smartphone. This low-cost system improves irrigation efficiency and can be used for both small gardens and large agricultural fields.

[3] An **IoT-based greenhouse monitoring and automatic watering system** was developed to improve plant growth and reduce manual irrigation. The system monitors **soil moisture, temperature, and humidity** using sensors and controls the water pump automatically through a **microcontroller integrated with the Blynk IoT platform**. The pump turns ON when the temperature exceeds **34°C** or humidity drops below **50%**, and turns OFF when normal conditions are restored. This system improves irrigation efficiency and helps maintain suitable environmental conditions for plant production.

[4] A **miniature automatic plant watering system** was developed using an **Arduino UNO** as the main controller. The system uses a **DHT22 sensor** to measure temperature and humidity, and an **RTC module** to schedule watering time. When the temperature exceeds **18°C** and soil moisture falls below **60%**, the controller activates a **water pump for about 3 minutes** to irrigate the plants. This system helps automate watering in greenhouse environments and reduces manual effort.

V. METHODOLOGY

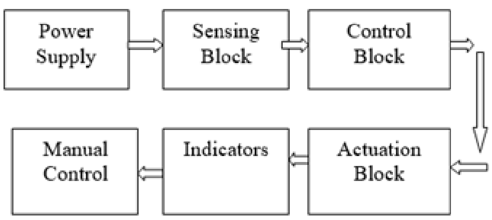

Fig. 1. V.HARDWARE COMPONENTS DESCRIPTION

BC558 PNP Transistor:

Fig. 2. BC558 PNP Transistor

The BC558 is a low-power PNP transistor commonly used for amplification and switching applications. In this circuit, it functions as the first stage that responds to the soil moisture sensor. When the soil becomes dry, the sensor output changes the base voltage, allowing the BC558 transistor to conduct and pass the signal to the next stage. This stage amplifies the weak sensor signal so that it can effectively trigger the BD139 transistor, which drives the relay connected to the water pump.

BC548NPN Transistor:

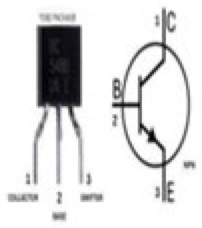

Fig. 3. BC548NPN Transistor

The **BC548** is a widely used NPN bipolar junction transistor suitable for low-power amplification and switching applications. It can handle a maximum collector current of 100 mA and a collector–emitter voltage of up to 30 V, making it appropriate for small electronic circuits and projects. Due to its stable performance, wide current gain range, and easy availability, the BC548 is commonly used in audio amplifiers, sensor circuits, signal processing applications, and general electronic switching systems.

LEDs:

Fig. 4. LEDs

The system uses 5 mm LEDs for both functional indication and decorative purposes. The red LED indicates the power ON or dry soil condition, alerting the user to low soil moisture. The green LED lights up when the water pump is active or when the soil moisture level is adequate, providing real-time visual feedback. The blue LED is mainly used for decorative purposes, enhancing the visual appearance of the system.

1KΩ Resistors:

Fig. 5. 1KΩ Resistors

Resistors and capacitors are essential components that help maintain the stability and reliability of an electronic circuit.

The 1 kΩ resistors act as current-limiting elements, preventing the LEDs from drawing excessive current and ensuring proper biasing of the transistors for correct switching operation. The 1000 µF capacitor is used to smooth ripple in the power supply and provide a stable DC voltage. The 470 µF capacitor helps absorb sudden voltage drops or spikes when devices such as relays or pumps switch on, thereby preventing circuit malfunction. Additionally, the 0.1 µF capacitor filters high-frequency noise, improving sensor accuracy and the overall response of the transistor switching circuit.

Capacitors(1000µF,470µF,0.1µF):

Fig. 6. Capacitors(1000µF,470µF,0.1µF)

Capacitors play an important role in maintaining power stability and ensuring smooth circuit operation. The 1000 µF capacitor acts as the main filter, smoothing out ripples from the power supply and providing a stable DC voltage to the system. The 470 µF capacitor offers additional support by handling sudden voltage drops or spikes that occur when the relay or pump switches, thereby preventing malfunction. The 0.1 µF capacitor functions as a noise filter, removing high-frequency disturbances and improving the sensitivity of the soil moisture sensor as well as the performance of the transistor switching circuit.

5VRelayModule:

Fig. 7. 5VRelayModule

A relay is an electromechanical switching device that allows a low-power signal to control a high-power load. It consists of a coil and a set of contacts: Common (COM), Normally Open (NO), and Normally Closed (NC). When a small voltage is applied to the coil, it becomes magnetized and moves the contact from the normally closed (NC) position to the normally open (NO) position, thereby completing the circuit and powering the connected device. When the voltage is removed, the coil is de-energized and the contact returns to its original position, turning the device off.

Soil Sensor Module:

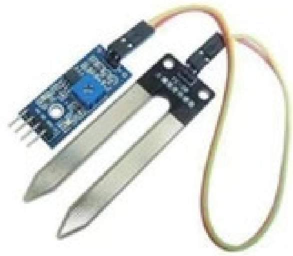

Fig. 8. Soil Sensor Module

The soil moisture sensor module serves as the primary sensing element of the system. It uses two metal probes inserted into the soil to detect moisture levels based on soil conductivity. When the soil is wet, the resistance between the probes decreases, producing a low output signal. In contrast, dry soil increases resistance and generates a higher output signal. This signal is then processed by the BC558 transistor, which further triggers the BD139 transistor and relay to activate the water pump. Jumper wires are used to provide convenient connections on the breadboard, enabling flexible testing and easy circuit modifications.

Breadboard:

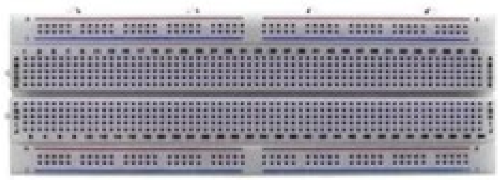

Fig. 9. Breadboard

The breadboard serves as the prototyping platform for this project. It allows easy insertion and rearrangement of electronic components without the need for soldering, making it ideal for testing, troubleshooting, and modifying circuits. The breadboard's interconnected rows and columns provide reliable connections, enabling rapid experimentation and learning. It also makes the circuit modular and portable, which is suitable for educational and mini-project applications.

LM7812VoltageRegulatorIC:

Fig. 10. LM7812VoltageRegulatorIC

The LM7812 is a three-terminal voltage regulator that provides a stable 12 V DC output from a higher input voltage. In this circuit, it ensures that the relay and water pump receive a steady power supply, preventing malfunctions caused by voltage drops or spikes. The regulator also includes built-in thermal and short-circuit protection, which improves the overall safety and reliability of the system.

LM7805VoltageRegulatorIC:

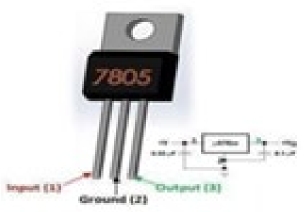

Fig. 11. LM7805VoltageRegulatorIC

The LM7805 is a voltage regulator that provides a stable 5 V DC output for low-voltage components such as the soil moisture sensor and LEDs. Working together with the LM7812, it forms a dual-voltage power supply system that supports both high-power and low-power sections of the circuit. This ensures that each component receives the appropriate and stable voltage, thereby improving the safety and operational reliability of the control electronics.

1N4007Diode:

Fig. 12. 1N4007Diode

The 1N4007 is a standard rectifier diode rated for 1000 V and 1 A, commonly used for protection in switching circuits. In this project, it is connected in reverse bias across the relay coil and functions as a flyback (freewheeling) diode. When the relay is turned OFF, the collapsing magnetic field in the coil generates a high reverse-voltage spike that can damage the BD139 transistor. The 1N4007 safely redirects this voltage spike by allowing the induced current to circulate through the coil until it dissipates. This protects the transistor from damage, reduces electrical noise, improves switching reliability, and increases the overall durability of the automatic watering system.

Bridge Rectifier:

Fig. 13. Bridge Rectifier:

The bridge rectifier converts AC voltage from the transformer into pulsating DC. It consists of four diodes arranged in a bridge configuration, allowing both halves of the AC waveform to contribute to the DC output. The resulting pulsating DC is then filtered using capacitors to obtain a smoother DC voltage for the voltage regulator ICs. The bridge rectifier plays an important role in safely and efficiently supplying DC power to the circuit from an AC mains source.

12-0-12Transformer:

Fig. 14. 12-0-12Transformer:

A 12-0-12 transformer is a step-down transformer that converts high AC mains voltage (typically 230 V or 120 V) into a lower and safer voltage suitable for electronic circuits. It has a center-tapped secondary winding that provides two 12 V AC outputs with a common ground (0 V). This configuration allows it to be used in both single and dual power supply circuits. In many electronic systems, including power regulator and control circuits, the 12-0-12 transformer supplies AC power that is later converted into DC for the proper operation of components such as relays, voltage regulators, and sensors. This type of transformer is reliable and well suited for medium-power electronic applications.

Water Pump

Fig. 15. Water Pump

The water pump in this project is used to supply water to the plants automatically when the soil becomes dry. When the moisture sensor detects low soil moisture, the relay is activated and powers the pump. The pump then draws water from the storage tank and delivers it through a pipe to the plant bed. As the pump operates, water is supplied to the soil until the required moisture level is reached. Once the sensor detects sufficient moisture, the relay switches off and the pump stops, thereby preventing overwatering.

VI. RESULT

A. Case1:When the soil is Dry

When the soil becomes dry, the moisture sensor detects high resistance and activates the BC558 transistor. This provides base current to the BC548 transistor, causing it to switch ON. As a result, the relay coil is energized and its contacts close, allowing the water pump to start watering the plants. The 1N4007 diode connected across the relay coil protects the BC548 transistor from voltage spikes generated during relay switching. The pump continues to operate until the soil reaches the required moisture level. Once sufficient moisture is detected, the sensor turns the transistors OFF, the relay becomes de-energized, and the pump stops automatically.

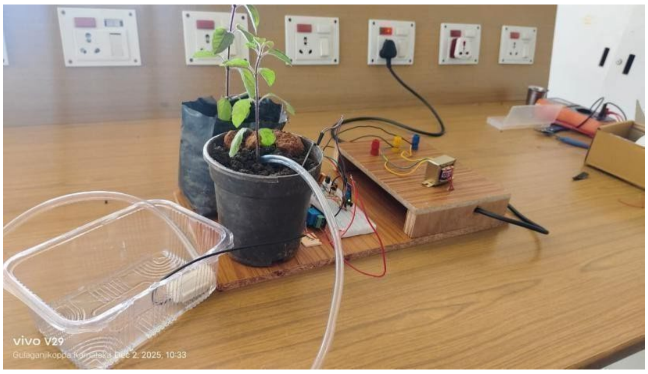

Fig. 16. Case1:When the soil is Dry

B. Case2:When the Soil isWet

Fig. 17. Case2:When the Soil isWet

When the soil is wet, the moisture sensor detects low resistance, producing a signal that keeps the BC558 transistor OFF. As a result, the BC548 transistor also remains OFF, the relay coil is de-energized, and the relay contacts stay open. Therefore, the water pump does not operate. This prevents overwatering and ensures that plants receive water only when necessary. The 1N4007 diode connected across the relay coil protects the circuit from voltage spikes during switching.

The decorative automatic garden watering system effectively controls irrigation based on soil moisture conditions. When the soil becomes dry, the sensor detects high resistance, which activates the transistor switching circuit and energizes the relay, turning ON the water pump to supply water to the plants. Once the soil reaches the required moisture level, the sensor detects low resistance, the transistors turn OFF, and the relay becomes de-energized, stopping the pump. This process ensures that plants receive water only when required, preventing overwatering, conserving water, and maintaining optimal soil moisture automatically without human intervention.

VII. ADVANTAGES, DISADVANTAGES AND APPLICATIONS.

A. Advantages

- **Automatic Watering:** The system automatically waters plants when the soil becomes dry, eliminating the need for constant manual monitoring and preventing both overwatering and underwatering.
- **Simple and Low-Cost Circuit Design:** The circuit uses basic electronic components such as transistors and relays, making the design simple, economical, and easy to implement.
- **Energy and Water Efficiency:** The water pump operates only when required, helping to conserve both electrical energy and water.
- **Status Indication through LEDs:** Colored LEDs provide clear visual indications of system status, such as power ON, watering activity, and adequate soil moisture levels.
- **Easy Setup and Troubleshooting:** The use of a breadboard allows easy circuit assembly, component replacement, and troubleshooting during testing and experimentation.
- **Compact and Cost-Effective Design:** The system uses commonly available components such as BC558, BC548, LM7812, LM7805, and 1N4007 diodes, making it inexpensive and easy to build.

B. Disadvantages

- **Higher Initial Setup Cost:** The system requires components such as a water pump, pipes, sensors, and a power supply, which may increase the initial installation cost.
- **Regular Maintenance Required:** Components such as pipes, pumps, and sensors may require periodic maintenance, as pipes can leak, nozzles may clog, and sensors may require recalibration.
- **Possibility of Overwatering or Underwatering:** If the sensor or circuit malfunctions, the plants may receive too much or too little water.
- **Power Dependency:** The system depends on a continuous power supply, and it may stop functioning during power failures unless a backup power source is used.

C. Applications

- **Educational Demonstrations:** The system is useful for demonstrating practical electronic concepts such as sensors, transistor switching, and relay operation for students.
- **Greenhouses and Nurseries:** It can be used in small greenhouses or nurseries to automate plant watering and maintain proper soil moisture levels.
- **Hydroponic Systems:** The system can be adapted for hydroponic setups where maintaining proper moisture levels is essential for plant growth.
- **Science Exhibitions:** The decorative LED indicators and automatic operation make the project visually attractive for science fairs and technical exhibitions.
- **Hands-on Learning Tool:** It helps students understand sustainable water usage, energy efficiency, and basic automation through a practical working circuit.

VIII. CONCLUSION

The Decorative Automatic Garden Watering System without Arduino demonstrates a simple, reliable, and cost-effective approach to automating plant irrigation. The system utilizes basic electronic components such as a soil moisture sensor, transistor-based control circuitry, a relay, and a regulated power supply to continuously monitor soil conditions. When the soil becomes dry, the system automatically activates the water pump to supply water as required. This reduces manual effort, prevents overwatering and underwatering, and supports healthier plant growth.

- In addition to improving plant health and water efficiency, the system enhances convenience and sustainability in garden maintenance. The use of LED indicators allows users to easily monitor the system status, while the compact and portable design makes it suitable for home gardens, indoor plants, decorative pots, greenhouses, and small-scale agricultural applications. Furthermore, the use of low-cost components and simple assembly makes this project an effective educational tool for students to understand sensor interfacing, transistor switching, and basic automation concepts in practical electronic systems.

IX. FUTURE WORK

In the future, the system can be enhanced by integrating wireless monitoring or IoT technology to allow remote control and real-time monitoring through a mobile application. Additional sensors such as temperature and humidity sensors can also be incorporated to improve irrigation efficiency and support smarter plant care.

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