AUTOMATED IRRIGATION CONTROL SYSTEM BASED ON ENVIRONMENTAL SENSING

TEAM MEMBERS:

- *Pradeeban S*
- *Ragul E*
- *Santhosh Kumar S*
- *Mohamed Ashaan S*

AIM:

To design and implement an **automated irrigation control system** that efficiently manages water delivery to crops by sensing environmental factors such as **soil moisture, temperature, and humidity, using the ESP8266 microcontroller** for real-time monitoring, control, and remote management.

COMPONENTS REQUIRED:

- ESP8266 microcontroller
- Soil moisture sensor
- DHT22 temperature and humidity sensor
- Water level sensor
- Motor pump
- Relay module (2 channel)
- Power supply
- OLED display
- LED
- Connecting wires

FUNCTIONS:

1. ESP8266 Microcontroller

- **Purpose:** Acts as the central controller, processing sensor data, controlling irrigation actuators, and providing Wi-Fi connectivity for remote monitoring.
- **Range & Features:** Operates at 3.3V, has multiple GPIO pins, supports Wi-Fi.
- **Working Levels:** Logic level at 3.3V (input voltage max 3.6V); operating temperature -40°C to +125°C.
- **Why Use:** Cost-effective, widely supported, low power with IoT capability.

2. Soil Moisture Sensor

- **Purpose:** Measures volumetric water content in soil.
- **Range:** 0% (dry) to 100% (saturated).
- **Operating Voltage:** Typically 3.3V to 5V.
- **Working Levels:** Provides analog voltage corresponding to soil moisture level; threshold typically around 30-40% moisture for irrigation trigger.
- **Why Use:** Directly measures soil condition to avoid over/under irrigation.

3. DHT22 Temperature and Humidity Sensor

- **Purpose:** Measures ambient temperature and relative humidity.
- **Range:** Temperature -40°C to +80°C (±0.5°C accuracy), Humidity 0-100% RH (±2-5% accuracy).
- **Operating Voltage:** 3.3V to 5V.
- **Working Levels:** Digital output signal, sensor wakes on request.
- **Why Use:** Environmental data helps adjust irrigation based on climate conditions

4. Relay Module

- **Purpose:** Electrically isolates and switches water pumps or solenoid valves.
- **Range:** Controls AC or DC loads; relay coil operates at 5V (can be controlled from ESP8266 with a transistor).
- **Max Load:** Typically 10A/250V AC or 10A/30V DC.
- **Working Levels:** Input control signal from ESP8266 GPIO pin.
- **Why Use:** Necessary for switching high voltage/current devices safely.

5. Water Level Sensor

- **Purpose:** Monitors water level in storage tanks.
- **Range:** Usually three-point detection - low, medium, high (can be customized).
- **Operating Voltage:** 3.3V to 5V.
- **Working Levels:** Digital or analog output.
- **Why Use:** Prevents pump dry-run by alerting low water levels.

6. Power Supply

- **Purpose:** Provides stable power to ESP8266, sensors, and relays.
- **Specification:** 5V regulated supply, with 3.3V regulator for ESP8266.
- **Why Use:** Ensures system reliability and component safety.

7. Motor Pump

- **Purpose:** Pumps water from the storage tank to the field when irrigation is activated.

- **Operating Range:** Typical small DC pumps run on 6V to 12V, with currents around 0.5A to 2A.
- **Why Use:** Essential for delivering water; controlled remotely by the relay module.
- **Max/Min Levels:** Voltage must match pump specs; overvoltage can damage the pump, undervoltage may reduce performance.

8. OLED Display

- **Purpose:** Provides real-time system feedback locally, such as soil moisture, temperature, and pump status.
- **Range:** Small displays often 0.96 to 1.3 inches diagonally; operating voltage typically 3.3V.
- **Why Use:** Offers quick, on-site status without needing external devices.
- **Working Levels:** Driven via I2C (uses GPIO pins D1 for SCL, D2 for SDA).

9. LED Indicators

- **Purpose:** Provide visual signals for system states (e.g., power on, irrigation active, alert).
- **Range:** Typically 3V forward voltage with 20mA current.
- **Why Use:** User-friendly indication to quickly understand system status.
- **Working Levels:** Use series resistors; exceeding ratings will burn out the LED.

10. Breadboard

- **Purpose:** Temporary platform to build and test the circuit without soldering.
- **Range:** Supports standard 0.1 inch pin spacing compatible with ESP8266 and sensors.
- **Why Use:** Enables easy prototyping and debugging.

11. Connecting Wires

- **Purpose:** To connect all components, transmit signals, and power between modules.
- **Range:** Typically 22 to 28 AWG stranded or solid wires.
- **Why Use:** Reliable, flexible medium for electrical connections.

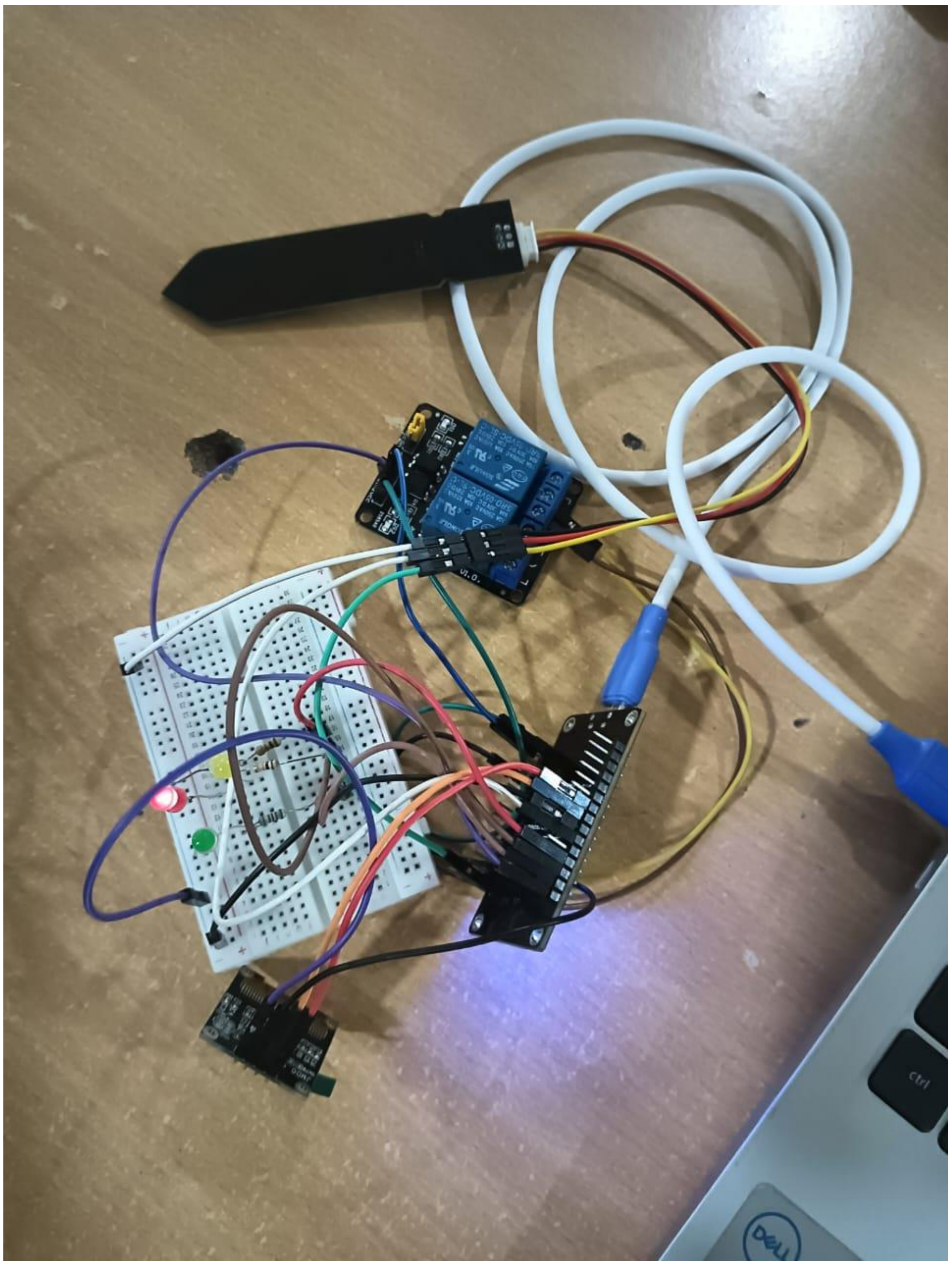
PIN DIAGRAM:

ESP8266 Pin Configuration (NodeMCU Typical)

Pin Name	GPIO Number	Function
D0	GPIO16	Can be used for sensor input
D1	GPIO5	I2C SCL (optional for sensors)
D2	GPIO4	I2C SDA (optional for sensors)
A0	ADC0 (Pin)	Analog input (e.g., soil sensor)
D5	GPIO14	Relay control output
D6	GPIO12	Relay control output or sensor
D7	GPIO13	General purpose I/O
3V3	Power	3.3V power supply
GND	Power Ground	Ground reference

Circuit Connection Diagram (Summary)

- Soil Moisture Sensor analog output to ESP8266 A0 pin.
- DHT22 data pin connected to GPIO D4 (GPIO2).
- Relay module input connected to GPIO D5 or D6 through transistor driver circuit.
- Relay common connected to pump or valve power line.
- Water level sensor to GPIO D7 (optional).
- ESP8266 powered with 3.3V regulated supply.
- Common GND for all components.



FLOW CHART

```
Start
↓
Initialize system (pins, serial)
↓
Read soil moisture sensor value
↓
Is moisture < thresholdLow
├– Yes → Turn ON pump (relay ON), Blink LED1 (Dry)
└─ No → Turn OFF pump
↓
Is moisture < thresholdMid
├– Yes → Turn ON pump (relay ON), Blink LED2 (Moderate)
└─ No → Turn OFF pump (relay OFF), Blink LED3 (Wet)
↓
Wait for 1 second
↓
Repeat
```

CODE SNIPPET

```
// Pin definitions using GPIO numbers
#define RELAY_PIN 5    // GPIO5 (D1) -> Relay IN1
#define SCL_PIN   14   // GPIO14 (D5) -> OLED SCL
#define SDA_PIN   12   // GPIO12 (D6) -> OLED SDA
#define SOIL_PIN  A0   // Analog pin (A0) -> Soil sensor
// Extra LEDs
#define LED1_PIN  4    // GPIO4 (D2)
#define LED2_PIN  0    // GPIO0 (D3)
#define LED3_PIN  2    // GPIO2 (D4)
void setup() {
  Serial.begin(115200);
  // Relay setup
  pinMode(RELAY_PIN, OUTPUT);
  digitalWrite(RELAY_PIN, HIGH); // Relay OFF initially (active LOW)
  // I2C pins (just declared, not used without OLED library)
  pinMode(SCL_PIN, OUTPUT);
  pinMode(SDA_PIN, OUTPUT);
  // LED pins
  pinMode(LED1_PIN, OUTPUT);
  pinMode(LED2_PIN, OUTPUT);
  pinMode(LED3_PIN, OUTPUT);
  // Start with all LEDs OFF
  digitalWrite(LED1_PIN, LOW);
  digitalWrite(LED2_PIN, LOW);
  digitalWrite(LED3_PIN, LOW);
  Serial.println("System Ready");
}
void loop() {
```

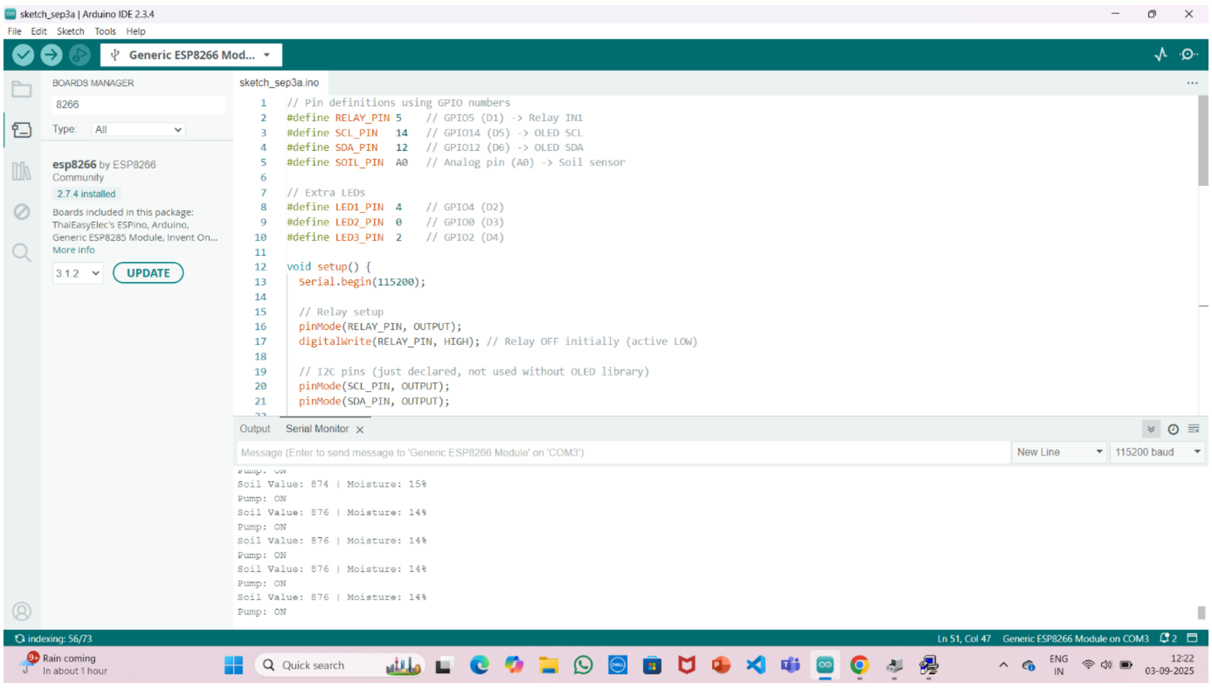
```
int soilValue = analogRead(SOIL_PIN);
// Convert to percentage (0=wet, 1023=dry)
int moisturePercent = map(soilValue, 1023, 0, 0, 100);
// Print values
Serial.print("Soil Value: ");
Serial.print(soilValue);
Serial.print(" | Moisture: ");
Serial.print(moisturePercent);
Serial.println("%");
// Relay control: pump ON if soil moisture < 40%
if (moisturePercent < 40) {
  digitalWrite(RELAY_PIN, LOW);  // Relay ON
  Serial.println("Pump: ON");
} else {
  digitalWrite(RELAY_PIN, HIGH); // Relay OFF
  Serial.println("Pump: OFF");
}
// LED indicators (example usage)
if (moisturePercent < 30) {
  digitalWrite(LED1_PIN, HIGH); // Very dry
  digitalWrite(LED2_PIN, LOW);
  digitalWrite(LED3_PIN, LOW);
} else if (moisturePercent < 60) {
  digitalWrite(LED1_PIN, LOW);
  digitalWrite(LED2_PIN, HIGH); // Moderate
  digitalWrite(LED3_PIN, LOW);
} else {
  digitalWrite(LED1_PIN, LOW);
  digitalWrite(LED2_PIN, LOW);
```

```
    digitalWrite(LED3_PIN, HIGH); // Wet
  }

  delay(2000);
}
```

Execution and Testing

- Power the ESP8266 and connect sensors as per circuit.
- Upload the code to ESP8266 using Arduino IDE.
- Observe serial monitor for real-time sensor readings and relay activity.
- Place soil moisture sensor in dry and wet soil to test irrigation trigger.
- Verify relay correctly switches the water pump/valve.
- Optionally integrate with cloud platforms for remote monitoring.
- Adjust soil moisture threshold values to optimize watering schedule as per crop needs.


sketch_sep3a | Arduino IDE 2.3.4
File Edit Sketch Tools Help
Generic ESP8266 Mod...
BOARDS MANAGER
8266
Type: All
esp8266 by ESP8266 Community
2.7.4 installed
Boards included in this package: ThaiEasyElec's ESPino, Arduino, Generic ESP8285 Module, Invent On...
More info
3.1.2
UPDATE
sketch_sep3a.ino
Output
Serial Monitor
Message (Enter to send message to 'Generic ESP8266 Module' on 'COM3')
New Line
115200 baud
indexing: 56/73
Ln 51, Col 47
Generic ESP8266 Module on COM3
Rain coming
In about 1 hour
Quick search
ENG IN
12:22
03-09-2025

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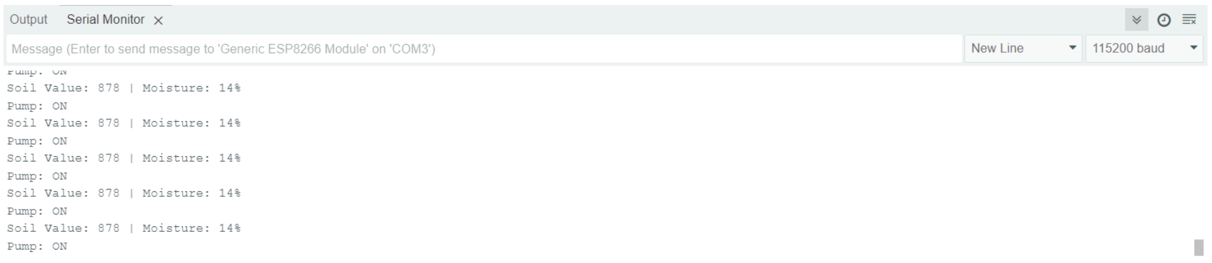
  digitalWrite(RELAY_PIN, HIGH); // Relay OFF initially (active LOW)

  // I2C pins (just declared, not used without OLED library)
  pinMode(SCL_PIN, OUTPUT);
  pinMode(SDA_PIN, OUTPUT);
```

```
Pump: ON
Soil Value: 874 | Moisture: 15%
Pump: ON
Soil Value: 876 | Moisture: 14%
Pump: ON
Soil Value: 876 | Moisture: 14%
Pump: ON
Soil Value: 876 | Moisture: 14%
Pump: ON
Soil Value: 876 | Moisture: 14%
Pump: ON
```


Output Serial Monitor

Message (Enter to send message to 'Generic ESP8266 Module' on 'COM3')

New Line 115200 baud

```
Pump: ON
Soil Value: 878 | Moisture: 14%
Pump: ON
Soil Value: 878 | Moisture: 14%
Pump: ON
Soil Value: 878 | Moisture: 14%
Pump: ON
Soil Value: 878 | Moisture: 14%
Pump: ON
Soil Value: 878 | Moisture: 14%
Pump: ON
```

RESULT:

The automated irrigation system demonstrated reliable and efficient operation by continuously sensing environmental factors and activating irrigation based on data-driven decisions. It helps conserve water, reduces manual intervention, and enhances crop productivity. The results affirm that this system can be deployed in agricultural settings to improve irrigation practices sustainably.