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SMART PLANT MONITORING SYSTEM

IOT Term Project Report

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Session: 2022–2026

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Smart Plant Monitoring System

1. Project Overview:
The Smart Plant Monitoring System is designed to automate and optimize plant care using multiple sensors and actuators connected through ESP32-WROOM microcontrollers. Sensor data is processed using MicroPython in Thonny IDE, while a Flask-based server facilitates communication between the microcontrollers . The system ensures the plant environment remains optimal through real-time monitoring and automatic actions.

2. Components Used:

2.1 Sensors:

- **MQ2 Gas Sensor**: Detects the presence of combustible gases. Used to monitor harmful gas accumulation in the plant environment.
- **MQ135 Gas Sensor**: Measures air quality by detecting various harmful gases like CO2 and ammonia. Ensures the air is safe for plant growth.
- **DHT11 Sensor**: Monitors temperature and humidity. Essential for maintaining ideal growing conditions.
- **Soil Moisture Sensor**: Measures the moisture content in the soil. Helps determine when the plant needs watering.
- **Water Level Sensor**: Detects the water level in the tank/reservoir. Ensures the water supply for irrigation is adequate.
- **YL-83 Rain Sensor**: Detects rainfall. Prevents overwatering by disabling the pump during rain.

2.2 Actuators:

- **Air Circulation Fan**: Activates when high humidity or gas levels are detected to circulate fresh air.
- **Exhaust Fan**: Engages when harmful gases are detected to expel them from the environment.
- **Submersible Water Pump (5V)**: Waters the plant when soil moisture levels are low and rain is not detected.
- **Heater (12V)**: Turns on when temperature falls below the optimal level for plant growth.
- **Relay Modules**: Used to control high voltage/current devices like fans, pumps, and heaters.
- **LCD Display**: Shows real-time sensor data and system status.
- **Buzzer**: Alerts users when critical conditions like gas leaks or low water levels are detected.
- **MOSFET Motor Driver Module:** Used to control the speed of DC actuators like fans and water pumps through PWM signals.

3. Working Mechanism:

1. **Data Collection**:
    - All sensors connected to ESP32 modules collect real-time environmental data.
    - Data includes temperature, humidity, gas levels, soil moisture, water level, and rainfall detection.

2. **Data Communication**:
    - Sensor data is transmitted to a Flask server via Wi-Fi.
    - Flask server processes the data and decides which actions to perform based on predefined thresholds.

3. **Action Execution**:
    - Based on the received data:
        - If gas levels are high: Exhaust fan is turned on and buzzer is activated.
        - If humidity is high: Air circulation fan is activated.
        - If temperature is low: Heater is turned on.
        - If soil is dry and no rain is detected: Water pump is activated.
        - If water tank is empty: Buzzer alerts user.
    - The relay modules are used to control these actuators accordingly.

4. **User Interface**:
    - An LCD displays current status and sensor readings.
    - Alerts are provided via buzzer.
    - The system can be monitored or controlled remotely via the Flask web interface.

4. Technologies Used:

- **Microcontrollers**: ESP32-WROOM
- **Programming Language**: MicroPython (for microcontrollers), Python (for Flask server)
- **Development Environment**: Thonny IDE, Flask
- **Communication**: Wi-Fi-based data transmission between ESP32 and Flask server

5. Conclusion:

- This Smart Plant Monitoring System automates crucial aspects of plant care, improving efficiency and reducing manual intervention. It is scalable, reliable, and provides a real-time solution for maintaining a healthy plant environment using IoT technologies.

Sensors information

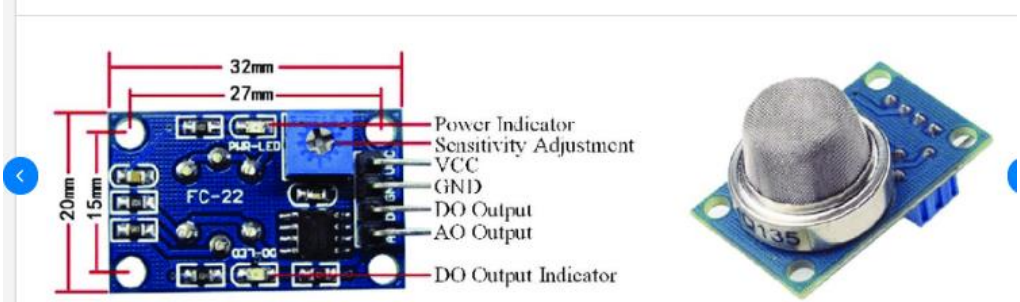
➢ MQ-2 Sensor

The MQ-2 sensor is a versatile and widely used gas sensor that is capable of detecting a range of gases and smoke in the environment. It operates on the principle of chemical resistance change. Inside the sensor, there is a sensing element composed of a microcrystalline tin dioxide (SnO2) semiconductor. This element's resistance decreases when it comes into contact with certain gases, making it an effective gas detector.

Key Features of the MQ-2 Sensor

- **Gas Detection**: The MQ-2 can detect various gases, including methane (CH4), butane (C4H10), propane (C3H8), carbon monoxide (CO), hydrogen (H2), and smoke.
- **Analog Output**: It provides an analog output voltage that corresponds to the gas concentration detected, making it compatible with microcontrollers like Arduino.
- **Fast Response Time**: The sensor offers a fast response time, enabling real-time monitoring and rapid alerts in case of gas or smoke detection.
- **Low Cost**: One of the most attractive aspects of the MQ-2 sensor is its affordability, making it accessible for DIY enthusiasts and small-scale projects.

➢ MQ-135



(Color online) MQ-135 gas sensor.

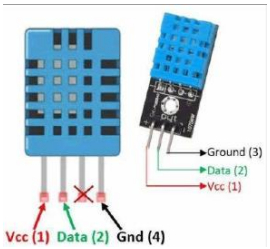
An MQ135 air quality sensor is one type of MQ gas sensor used to detect, measure, and monitor a wide range of gases present in air like ammonia, alcohol, benzene, smoke, carbon dioxide, etc. It operates at a 5V supply with 150mA consumption. Preheating of 20 seconds is required before the operation, to obtain the accurate output

Where to Use/Applications of MQ135 Air Quality Sensor:

The applications of the MQ135 quality sensor are,

- Used in the detection of excess or leakage of gases like nitrogen oxide, ammonia, alcohol, aromatic compounds, smoke, and sulfide.
- Used as air quality monitors.
- Used in air quality equipment for offices and buildings.
- Used as a domestic air pollution detector.
- Used as an industrial air pollution detector.
- Works as a portable air pollution detector.

➢ Temperature sensor(DHT11)



Working Principle of DHT11 Sensor

DHT11 sensor consists of a capacitive humidity sensing element and a thermistor for sensing temperature. The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measure, process this changed resistance values and change them into digital form.
For measuring temperature this sensor uses a Negative Temperature coefficient thermistor, which causes a decrease in its resistance value with increase in temperature. To get larger resistance value even for the smallest change in temperature, this sensor is usually made up of semiconductor ceramics or polymers.

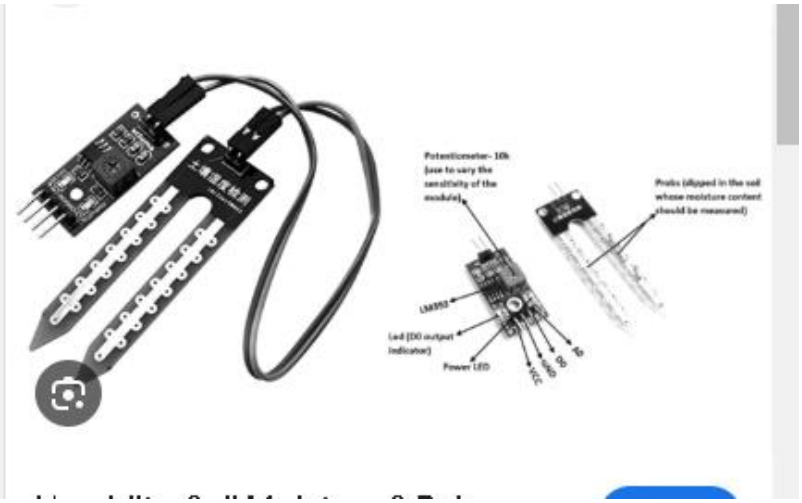
The temperature range of DHT11 is from 0 to 50 degree Celsius with a 2-degree accuracy. Humidity range of this sensor is from 20 to 80% with 5% accuracy. The sampling rate of this sensor is 1Hz .i.e. it gives one reading for every second. DHT11 is small in size with operating voltage from 3 to 5 volts. The maximum current used while measuring is 2.5mA.

Applications

- This sensor is used in various applications such as measuring humidity and temperature values in heating, ventilation and air conditioning systems.
- Weather stations also use these sensors to predict weather conditions.

- The humidity sensor is used as a preventive measure in homes where people are affected by humidity.
- Offices, cars, museums, greenhouses and industries use this sensor for measuring humidity values and as a safety measure

➢ Soil Moisture sensor



A **soil moisture sensor** works by measuring the **conductivity** or **capacitance** of the soil:

1. **Conductivity-Based Sensor (Resistive Type):**
    - Uses two probes inserted into the soil.
    - Measures **electrical resistance** between the probes.
    - **More water in the soil = Lower resistance (higher conductivity).**
    - **Less water in the soil = Higher resistance (lower conductivity).**
2. **Capacitive Sensor:**
    - Uses a capacitive plate to measure **dielectric permittivity**, which correlates with soil moisture levels.
    - More stable and **less prone to corrosion** than resistive sensors.

Use Case in IoT-Based Saffron Environment

- Ensures **optimal soil moisture** for saffron growth.
- Prevents **overwatering or underwatering**, which can harm saffron plants.
- Automates irrigation by **activating a water pump** when moisture drops below a threshold.
- Helps in **data logging** for soil conditions to improve crop yield

- The required voltage for working is 5V
- The required current for working is <20mA
- Type of interface is analog
- The required working temperature of this sensor is 10°C~30°C

The applications of moisture sensor include the following.

- Agriculture

- Landscape irrigation
- Research
- Simple sensors for gardeners

➢ Water Level Sensor

The operation of the water level sensor is fairly simple.

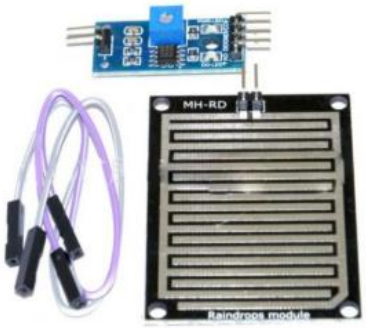
The power and sense traces form a variable resistor (much like a potentiometer) whose resistance varies based on how much they are exposed to water.

This resistance varies inversely with the depth of immersion of the sensor in water:

- The more water the sensor is immersed in, the better the conductivity and the lower the resistance.
- The less water the sensor is immersed in, the poorer the conductivity and the higher the resistance.

The sensor generates an output voltage proportional to the resistance; by measuring this voltage, the water level can be determined.

➢ YL-83 Rain Sensor



Working of YL-83 Rain Sensor

1. Components & Structure

The YL-83 rain sensor consists of:

- **Sensing Pad (Rain Board):** A PCB with conductive tracks.
- **Control Module:** Converts analog signals into digital output.
- **Comparator (LM393):** Determines whether rain is detected.

2. Working Principle

- When rain falls on the sensor's conductive tracks, it **reduces resistance** between them.
- This change alters the **voltage** passing through the sensor.
- The control module **processes the signal** and provides:
    - **Analog Output (AO):** Proportional to rain intensity.
    - **Digital Output (DO):** Activated when rain is detected (threshold set via a potentiometer).

3. Use Case in IoT-Based Saffron Environment

- Detects rain to **adjust irrigation schedules** automatically.
- Prevents **overwatering** by stopping the water pump when it rains.
- Can trigger **alerts or notifications** to inform users of rainfall conditions.

Actuators

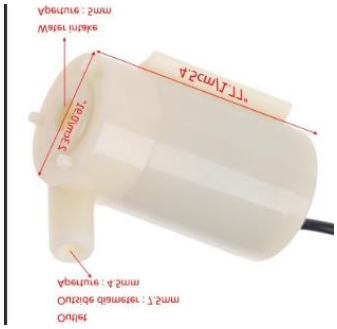
Working of Actuators

Actuators are devices that convert electrical signals into physical actions to control environmental conditions. In this project, they are used for **temperature regulation, irrigation, air circulation, and notifications**.

*1. **Fan (5V) - Air Circulation***

- **Working:**
  - The fan is controlled using **Pulse Width Modulation (PWM)** via a MOSFET.
  - When triggered, it circulates air to regulate humidity and temperature.
- **Use Case:**
  - Helps in **cooling** the environment when the temperature is too high.
  - Prevents **stagnant air** which can cause mold or fungal growth.

3. Submersible Water Pump (5V) - Irrigation System



- **Working:**
  - The pump operates using a **MOSFET switch** that allows PWM speed control.
  - It pumps water into the soil when the **soil moisture sensor** detects dryness.
- **Use Case:**
  - **Automated irrigation** to keep soil moisture at an optimal level for saffron.

4. Heater (12V) - Temperature Control

- **Working:**
  - The heater is controlled via a **MOSFET (IRF540N)**.
  - When the **temperature drops**, the heater turns on to maintain warmth.
- **Use Case:**
  - Ensures **ideal temperature conditions** for saffron cultivation.

5. Relay Module - Switching High-Power Devices

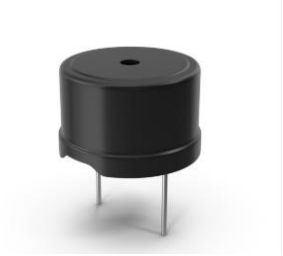
- **Working:**
  - Acts as a **switch** to control high-power devices like the heater or water pump.
  - The ESP32 sends a **digital HIGH/LOW signal** to trigger the relay.
- **Use Case:**
  - Controls **external devices safely** without directly exposing the ESP32 to high voltage.

6. LCD Display - Real-Time Data Monitoring

- **Working:**
  - Uses **I2C communication** to receive data from ESP32.
  - Displays sensor readings and actuator status.

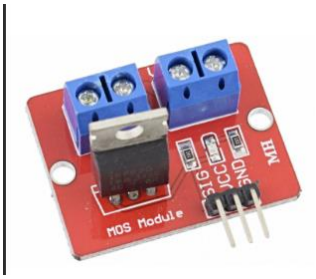
- **Use Case:**
    - Allows users to **visually monitor** environmental conditions.

7. Buzzer - Alerts & Notifications



- **Working:**
    - A **digital signal** from ESP32 turns the buzzer on/off.
    - Produces an alarm sound when specific conditions are met (e.g., gas leakage, low water level).
- **Use Case:**
    - **Alerts users** in case of critical environmental changes.

8. Motor Controllers – Speed Control



Working:
Motor controller modules (MOSFET-based) are integrated into the system to regulate the speed of the **air circulation fan** and **submersible water pump**. These modules use **Pulse Width Modulation (PWM)** signals from the ESP32 to adjust the speed dynamically based on environmental conditions.

Use Case:

- Fan speed is increased when higher humidity or temperature is detected, enhancing air circulation.
- Pump speed is modulated based on the level of soil dryness, allowing fine control over irrigation.

This enables energy-efficient operation and extends the life of the actuators while maintaining optimal environmental conditions.