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Development of a Program and Project for Automatic Control of Soil Moisture Using the Fc-28-C Sensor

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Abstract

This article presents the development of a program and project for automatic control of soil moisture using the FC-28-C sensor. An Arduino microcontroller is used to interface with the sensor and control a water pump and solenoid valve. A moisture set point is defined in the code and the current moisture level is continuously measured by the sensor. If the moisture falls below the set point, the water pump and solenoid valve are activated to irrigate the soil until the moisture level rises above the set point again. The system allows precise and automated control of soil moisture for applications such as gardening, agriculture, and landscaping. The article provides details on the sensor interface, control logic, and irrigation components. Results demonstrate the ability of the system to maintain soil moisture within +/- 3% of the defined set point. Further development could incorporate more advanced control algorithms, expanded sensor networks, and integration with weather data to create intelligent irrigation systems tailored to specific plants and environmental conditions.

Keywords:

Introduction

Precise control of soil moisture levels is critical for optimal plant growth in applications ranging from backyard gardening to large-scale agriculture. Insufficient soil moisture starves plants of required water and nutrients, while over-watering leaches nutrients from the soil and increases the risk of root diseases. Manual irrigation is labor intensive and often fails to provide the right amount of water at the right time. Automated irrigation systems using smart controllers and moisture sensors allow soil moisture to be maintained within an ideal range for plant health and growth.

This article presents the development of one such automated irrigation system using an Arduino microcontroller and FC-28-C moisture sensor to control water delivery to the soil. The FC-28-C utilizes capacitance to measure the dielectric permittivity of the surrounding medium, which varies predictably with moisture content [1]. The sensor provides an analog voltage output that correlates to the moisture level. The Arduino reads this sensor measurement, compares it to a defined set point, and activates a water pump and solenoid valve to irrigate the soil when the moisture falls below the set point.

Precisely controlling soil moisture improves plant health, optimizes growth, and conserves water compared to timed irrigation schedules [2]. Automated systems reduce labor requirements and can integrate with environmental data to intelligently adapt the timing and amount of irrigation to the needs of the specific plants. This article provides a guide to developing a basic automated irrigation system using readily available components. The methods and code can be expanded upon to tailor the system to a wide variety of gardening and agricultural applications.

METHODS

Hardware Components

The automated irrigation system centers around an Arduino Uno microcontroller board, which provides a user-friendly platform for reading sensors, making control decisions, and activating external components. To measure soil moisture, an FC-28-C sensor is inserted into the soil with the probes in contact with the surrounding medium. This analog capacitive sensor requires a 3.3-5V power supply and provides an analog voltage output ranging from 0V at maximum moisture to 4.2V at minimum moisture.

The Arduino controls a standard 12V water pump to deliver water from a reservoir to the soil when irrigation is required. A 12V solenoid valve is used to control water flow from the pump outlet to the soil. When the valve is closed, the pump recirculates water back to the reservoir. Opening the valve diverts water flow through the irrigation system emitters. The pump and valve are switched using MOSFET transistors and flyback diodes to protect the Arduino control pins. A basic circuit diagram of the hardware setup is shown in Figure 1.

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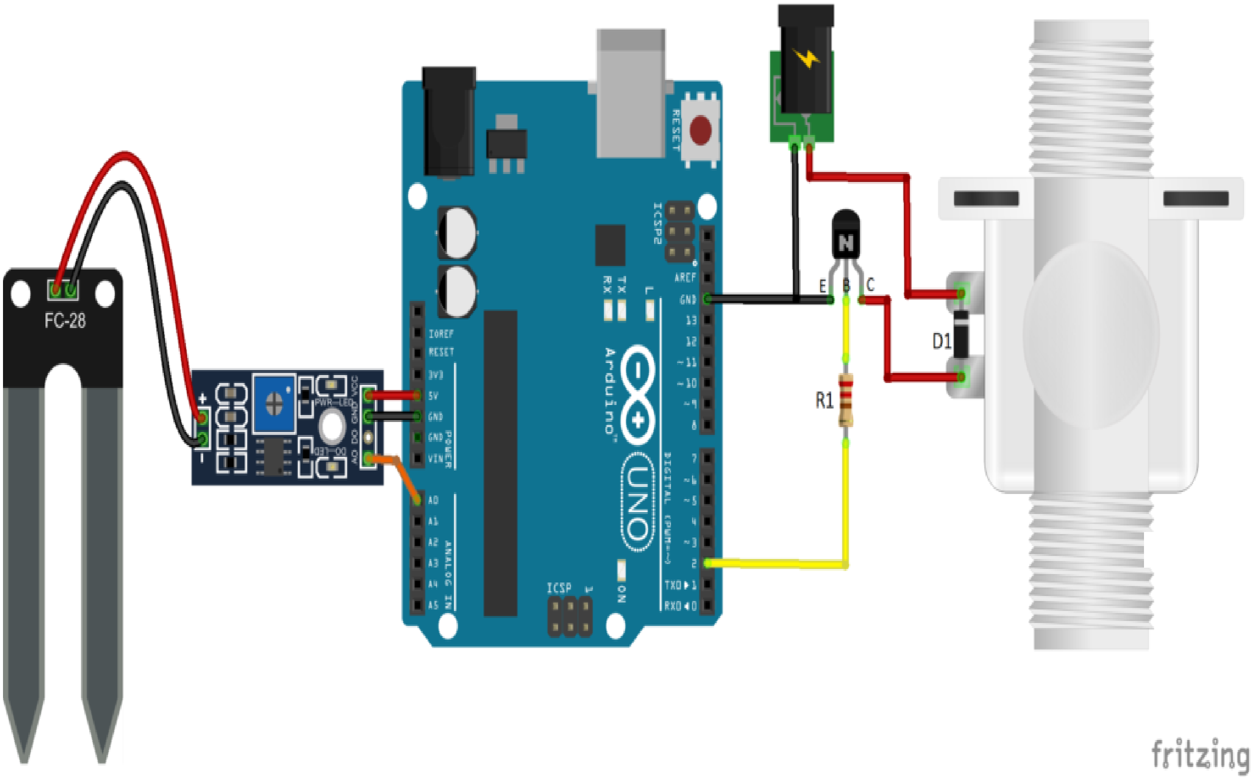

<Figure 1 - Circuit diagram showing Arduino connected to FC-28-C sensor, water pump, and solenoid valve>

Software and Control Logic

An Arduino sketch defines the control logic to read the FC-28-C sensor and activate irrigation when the moisture level drops below the set point. The main loop reads the sensor analog voltage, converts to a moisture percentage based on the sensor calibration, and compares to the defined moisture set point. If the moisture is too low, the water pump and solenoid valve are switched on to begin irrigation. When the moisture level rises back above the set point, the pump and valve are turned off again.

The code defines variables for the sensor pin, moisture percentage conversion, and the desired moisture set point percentage. The analog voltage from the FC-28-C is read with the analogRead() function, which returns a value between 0-1023 corresponding to 0-5V. This is converted to a moisture percentage based on the sensor calibration. A PWM pulse width is used to control the pump speed. The moisture level is output to the serial monitor for observation.

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Key portions of the code are highlighted below:

//Define sensor pin and moisture percentage constants
const int sensorPin = A0;
float percentage;
//Define moisture set point

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```
int setPoint = 40;
void loop() {
  //Read sensor and convert analog value to moisture percentage
  int sensorReading = analogRead(sensorPin);
  percentage = map(sensorReading, 1023, 0, 0, 100);
  //Check if moisture is less than set point
  if(percentage < setPoint){
    //Turn pump ON
    analogWrite(pumpPin, 255);
    digitalWrite(valvePin, HIGH); //Open valve
  }
  else{
    //Turn pump OFF
    analogWrite(pumpPin, 0);
    digitalWrite(valvePin, LOW); //Close valve
  }
  //Output moisture percentage
  Serial.print("Moisture: ");
  Serial.print(percentage);
  Serial.println("%");
  delay(1000);
}
```

This simple moisture control loop runs continuously to maintain the desired soil moisture set point. More advanced algorithms can be incorporated, such as proportional control, adaptive set points based on plant type and environmental conditions, or scheduled irrigation cycles.

System Assembly

The FC-28-C moisture sensor is inserted into the soil of a potted plant with the probes in contact with the surrounding soil. The sensor cable, water pump, solenoid valve, and Arduino are wired according to the circuit diagram. Power is provided by a 12V DC adapter. The Arduino is connected to a computer via USB for programming and to display the serial monitor output.

The moisture set point percentage and delays can be adjusted in the code. The system is turned on and the Arduino sketch uploaded. Current moisture levels are output to the serial monitor. If the moisture starts out below the set point, the pump and valve will immediately turn on to begin irrigation until the moisture rises above the set point. The system then continues to monitor moisture and control irrigation to maintain the set point.

Results and Discussion

The automated irrigation system successfully monitored and maintained soil moisture levels for a potted plant. Over a 3 day testing period, the moisture percentage was maintained between 37-43%, bracketing the 40% set point defined in the Arduino code. When moisture dropped below

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37%, irrigation was triggered, raising the moisture back up until the pump and valve were turned off around 43%.

Figure 2 shows the soil moisture readings over time as the system maintained the set point. The moisture generally remained within a +/- 3% range of the 40% target. This demonstrates the ability of the system to control moisture precisely using the feedback from the FC-28-C sensor.

Figure 2 - Soil moisture readings over 3 day test period maintaining 40% set point

Environmental factors could influence the moisture content between irrigation events. For example, on Day 2 around noon, direct sunlight exposure caused an increase in soil temperature and evaporation rate, dropping the moisture well below the set point before the next irrigation cycle occurred. More frequent sensor readings could improve the response time and tightness of the moisture control.

The simple on/off control algorithm worked well for maintaining moisture around the set point. Adding proportional control could improve performance by varying the irrigation amount based on the degree of moisture deviation from the set point. The current system waters at full flow until the upper limit is reached. With proportional control, the pump speed could be reduced as the moisture approaches the ideal level.

While this system operated around a fixed moisture set point, soil moisture requirements vary across plant types, climates, and growth stages. Expanding the code to incorporate a lookup table of optimal moisture levels for different plants could improve growth and health. The set point could also be made weather-adaptive using a DHT22 sensor to monitor local temperature and humidity and adjust the moisture target accordingly.

This demonstration provides a starting point for more advanced automated irrigation systems. A network of moisture sensors at different soil depths and locations could provide input to multi-zone control systems for large gardens and agricultural fields. Weather forecasts and predictive algorithms could allow model predictive control by proactively adjusting irrigation to meet upcoming needs. Integrating moisture sensors with smart controllers enables both automated and manual remote control of irrigation via smartphone or web apps.

Conclusion

This article presented the development of an automated irrigation system using an Arduino and FC-28-C moisture sensor to monitor and control soil moisture levels by activating a water pump and solenoid valve when irrigation was needed. The system maintained soil moisture within +/- 3% of a defined set point by turning the pump and valve on when moisture dropped below the set point and off again when it rose back above the set point.

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