The Automated Irrigation System for Small Mulberry Tree

This project focuses on designing an automated irrigation system using an Arduino microcontroller, a Real-Time Clock (RTC) module, an EEPROM module, and a relay. The main goal is to efficiently control the water supply for plants, ensuring they get adequate hydration while minimizing water waste. This is particularly useful for remote or small-scale setups, such as balcony gardens, where frequent monitoring isn't feasible.

Key Objectives

Before setting up the system, we need to calculate three key irrigation parameters:

1. **Weekly Water Requirement: The total water needed per week for the plant.**
2. **Irrigation Interval: How often the plant needs watering.**
3. **Water per Irrigation Event: The amount of water to supply each time.**

These calculations help customize the system for specific plants (in this case, a young mulberry tree). If the plant type changes, these values should be recalculated for accurate results.

System Components

- **Arduino Uno: The microcontroller controls the system's operation. Other microcontrollers can also be used.**
- **RTC Module (PCF8563): Tracks the time and date to schedule irrigations accurately.**
- **EEPROM (Internal/External): Stores the last irrigation date to ensure proper intervals between watering events. The Arduino's internal EEPROM can handle infrequent writes (every 3 days in this case), but if higher write frequency is needed, an external EEPROM like the AT24C256 is recommended.**
- **Water Pump (24V, 1.25 L/min flow): Delivers water to the plants through a drip irrigation hose.**
- **Relay Module (1 Channel): Controls the water pump.**
- **Drip Irrigation Hose and Water Tank: A 20-liter tank connected to a water pump ensures consistent water flow to the plant.** showing in figure 1 The connecting the hose to the plant

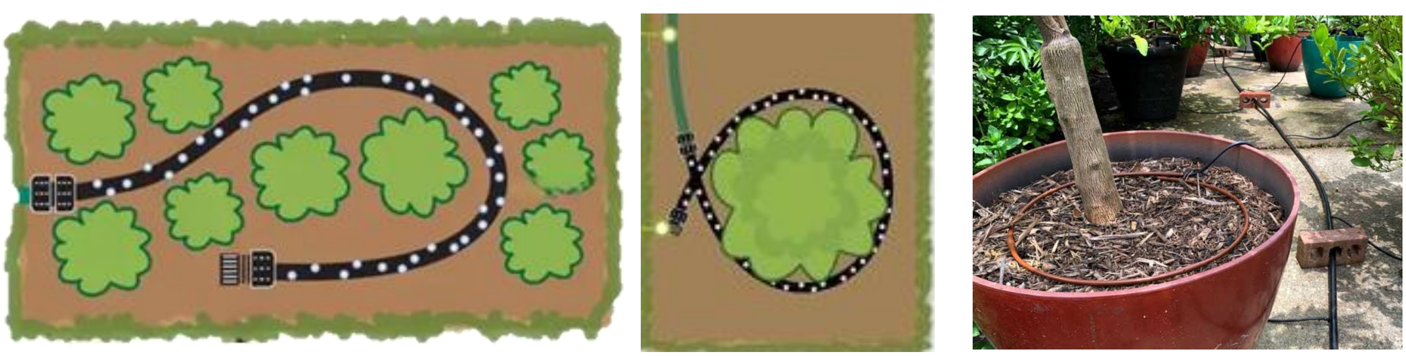

Figure 1

System Setup

1. **Calculate Irrigation Parameters: After calculating the Weekly Water Requirement, Irrigation Interval, and Water per Irrigation Event, we set up the system to meet these requirements.**
2. **Setup Hardware: Connect the hose to the water pump and position it for optimal water delivery to the plant.**
3. **Program the Arduino: The code is available on GitHub. It starts by calibrating the clock and storing the initial irrigation day in the EEPROM.**
4. **Control Watering Schedule: In the code, the void setup function is used once to calibrate the clock. In the void loop, the Arduino checks the current date. If it matches the scheduled irrigation day, the system activates the pump for a set duration (5 minutes in this case, based on the pump flow rate). After irrigation, the next irrigation date is stored in the EEPROM, taking month length into account to avoid scheduling errors.**

Example Calculation

- **For instance, if the current irrigation day is October 30, the system checks the month's day count to determine the next irrigation date. If the next watering is due in 3 days, the code adjusts for month-end transitions (e.g., from October 31 to November 2) to ensure continuous, accurate irrigation.** Figure 2 showing the code.

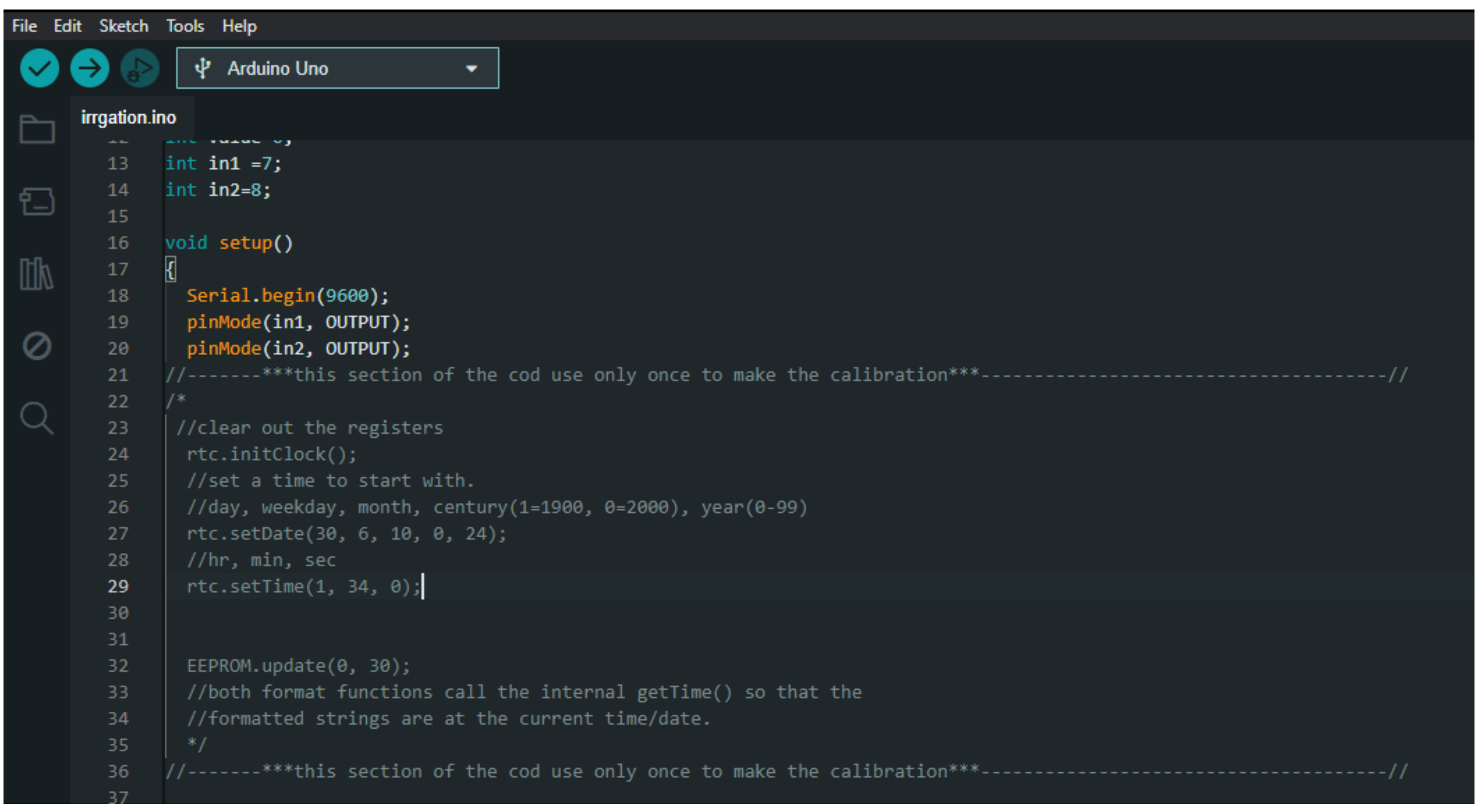

Figure 2

Circuit Overview and Main Components

1. Arduino Uno: The main control unit of the system, responsible for receiving time information from the RTC and controlling the relay to turn the water pump on and off according to a set schedule.
2. RTC (Real-Time Clock) - PCF8563: This component provides real-time tracking, allowing the Arduino to follow a programmed schedule. The RTC ensures that the irrigation system activates the water pump at specific times of the day, making the system more autonomous and precise.
3. Relay Module: The relay functions as an electronic switch, controlled by the Arduino. When the programmed time is reached, the Arduino activates the relay to turn on the water pump.
4. Water Pump: Connected to the relay, the pump supplies water to the plants. It operates on a timed schedule managed by the RTC and Arduino, ensuring consistent irrigation.
5. EEPROM - AT24C256: Used for non-volatile storage, allowing the system to save irrigation schedules and settings even if the power is turned off. This ensures that schedules are maintained without needing reprogramming after a reset.
6. Power Supply: Powers the circuit, including the Arduino, RTC module, and pump.

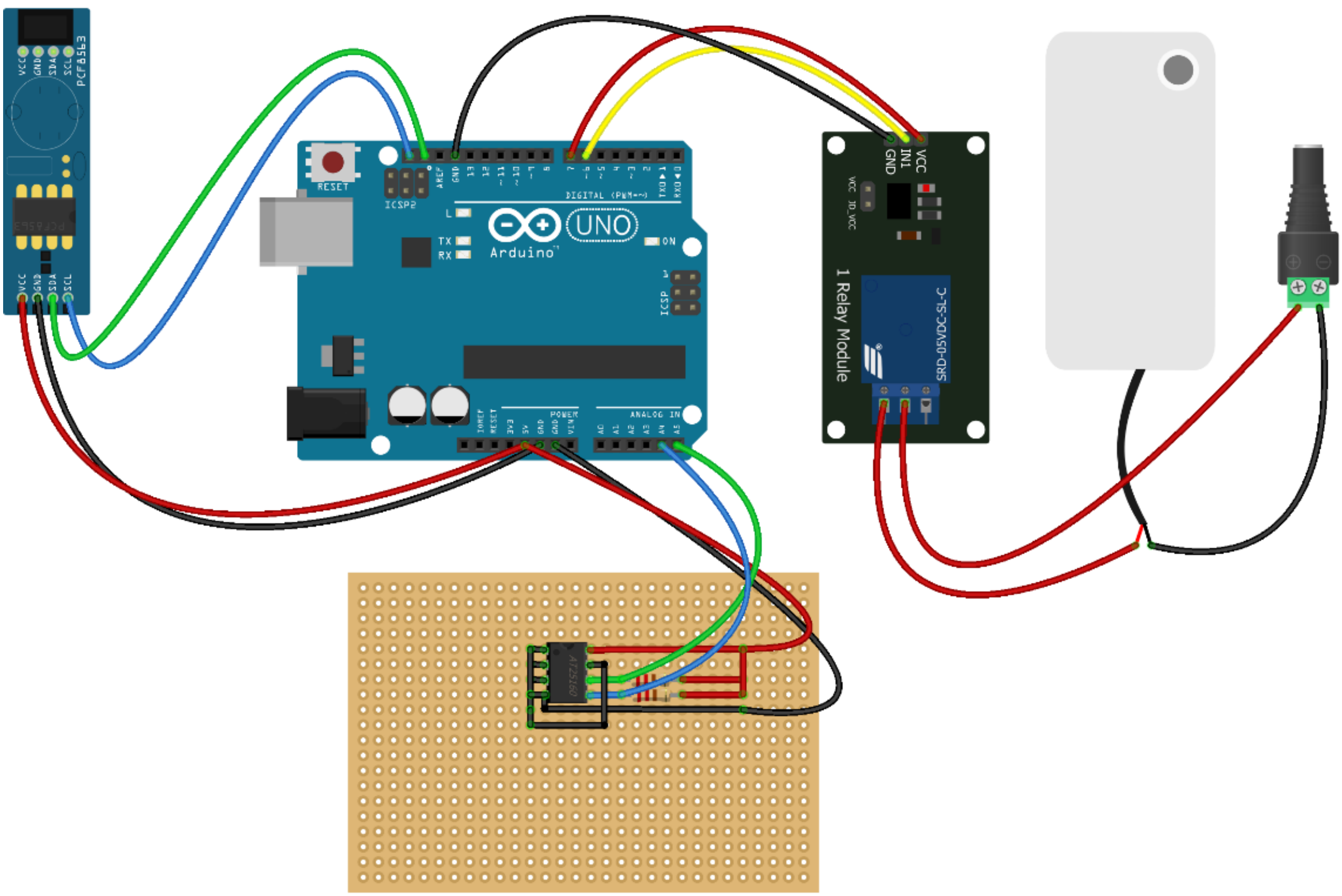

Figure 3 showing the schematic of the electronics components.

Irrigation Requirement

Plant Type: Small Mulberry Tree
Soil Type: Clayey Sandy
Location: Balcony
Assumptions: Moderate climate conditions

1. Calculation of Available Water Capacity (AW)

Available Water (AW) is the amount of water the soil can hold that is accessible to the plant.

- **Field Capacity ($\boldsymbol{\theta_{FC}}$)**: *0.25* (fraction)
- **Wilting Point ($\boldsymbol{\theta_{WP}}$)**: *0.10* (fraction)
- **Available Moisture ($\boldsymbol{\theta_m}$)**: $\boldsymbol{\theta_{FC} - \theta_{WP}} = 0.25 - 0.10 = 0.15$
- **Soil Bulk Density ($\boldsymbol{\gamma_b}$)**: *1400 Kg/m³*
- **Root Depth (D)**: *0.3 m*

Equation:

$$AW = \theta_m \times \gamma_b \times D$$

Calculation:

$$AW = 0.15 \times 1400 \times 0.3 = 63\ {}^{mm}/_{m}$$

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2. Crop Water Requirement ($\boldsymbol{d_n}$)

The water requirement is determined by the available water and the crop coefficient (P).

- **Crop Coefficient (P)**: 0.5 for small mulberry trees

Equation:

$$\boldsymbol{d_n} = AW \times D \times P$$

Calculation:

$$\boldsymbol{d_n} = 63 \times 0.3 \times 0.5 = 9.45\ mm$$

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3. Irrigation Water Requirement ($\boldsymbol{d_g}$)

To determine the irrigation water requirement, we factor in the application efficiency ($\boldsymbol{E_a}$).

- **Application Efficiency (E_a)**: 0.75
- **Leaching Requirement (LR)**: 0 (no additional salt leaching needed)

Equation:

$$d_g = \frac{d_n}{E_a \times (1 - LR)}$$

Calculation:

$$d_g = \frac{9.45}{0.75 \times (1 - 0)} = 12.6\, mm$$

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4. Weekly Water Volume

Given that the tree's root zone area is approximately 1 square meter:

Calculation:

$$Weekly\, Water\, Volume = d_g \times Area = 12.6 \text{ Liters}$$

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5. Frequency Between Irrigations (F)

To calculate the irrigation interval, we divide the plant's water requirement by the daily evapotranspiration rate (ET_c).

- **Daily Evapotranspiration (ET_c)**: Assumed 4 mm/day

Equation:

$$F = \frac{d_n}{ET_c}$$

Calculation:

$$F = \frac{9.45}{4} = 2.36 \approx 3\, days$$

Result: Approximately every 3 days.

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6. Water Volume per Irrigation

Assuming 3 irrigation events per week:

Equation:

$$\text{Water per Irrigation} = \frac{Weekly\ Water\ Volume}{\text{Number of Irrigation per Week}}$$

Calculation:

$$\text{Water per Irrigation} = \frac{12.6}{3} = 4.2\ Liters$$

Result: Approximately 4-4.5 liters per irrigation.

Summary

- **Weekly Water Requirement:** 12.6 liters
- **Irrigation Interval:** Every 3 days
- **Water per Irrigation Event:** 4-4.5 liters

References

- Principles of Irrigation Engineering by Jack Keller and Ronald D. Bliesner.