CPE final project report
Team Number 40
Team Members: Christopher Maldonado

My final project is an **embedded system swamp cooler** designed to provide energy-efficient cooling in dry climates. The cooler operates by pulling outside air through a water-soaked pad, where evaporation lowers the air temperature and increases humidity. The system is controlled by an **Arduino Mega 2560** microcontroller and integrates multiple sensors, actuators, and user interfaces to ensure safe and reliable operation.

The cooler cycles through four distinct **states**:

- **DISABLED**: System is off. Yellow LED indicator is lit. No monitoring or fan activity occurs.
- **IDLE**: System is on standby. Green LED is lit. Sensors continuously monitor water level, temperature, and humidity.
- **RUNNING**: Fan motor is active. Blue LED is lit. The system enters this state when temperature or humidity exceed thresholds.
- **ERROR**: Red LED is lit. Triggered when water level drops below the safe threshold. Fan is disabled until water is replenished.

Transitions between states are triggered by sensor readings or user inputs (start, reset, and vent control buttons). The LCD display provides real-time feedback on temperature, humidity, water level, and current state. The system also records timestamps of state changes using the RTC module, enabling logging and traceability.

Key functionalities:

- Automatic fan control based on temperature and humidity thresholds.
- Water level monitoring with hysteresis to prevent rapid toggling between ERROR and IDLE states.
- LED indicators for clear visual feedback of system state.
- LCD interface for sensor readings and state messages.
- Stepper motor vent control for adjusting airflow direction.
- Button inputs for start, reset, and manual vent adjustment.
- RTC logging of state transitions and vent movements for system traceability.

Component Details

1. Arduino Mega 2560

- The central microcontroller manages all inputs, outputs, and state transitions.
- Direct register manipulation is used for timers, ADC, and interrupts to meet project guidelines.

2. LiquidCrystal LCD (16x2)

- Displays sensor readings (temperature, humidity, water level) and system state.
- Provides user feedback during button presses and vent adjustments.

3. Stepper Motor (28BYJ-48 with ULN2003 driver)

- Controls the vent position to direct airflow.
- Operated via the Stepper library with defined steps per revolution.

4. Fan Motor

- Provides airflow for cooling.
- Controlled via a digital output pin (PB4) with a dedicated power supply board to protect the Arduino.

5. DHT11 Temperature and Humidity Sensor

- Measures ambient temperature (°F) and relative humidity (%).
- Readings determine transitions between IDLE and RUNNING states.

6. Water Level Sensor

- Connected to analog pin A0.
- ADC readings are compared against hysteresis thresholds (LOW_WTR and HIGH_WTR).
- Ensures safe operation by preventing fan activity when water is insufficient.

7. RTC DS3231 Module

- Provides accurate real-time clock functionality.
- Used to timestamp state transitions and vent movements for logging via the serial monitor.

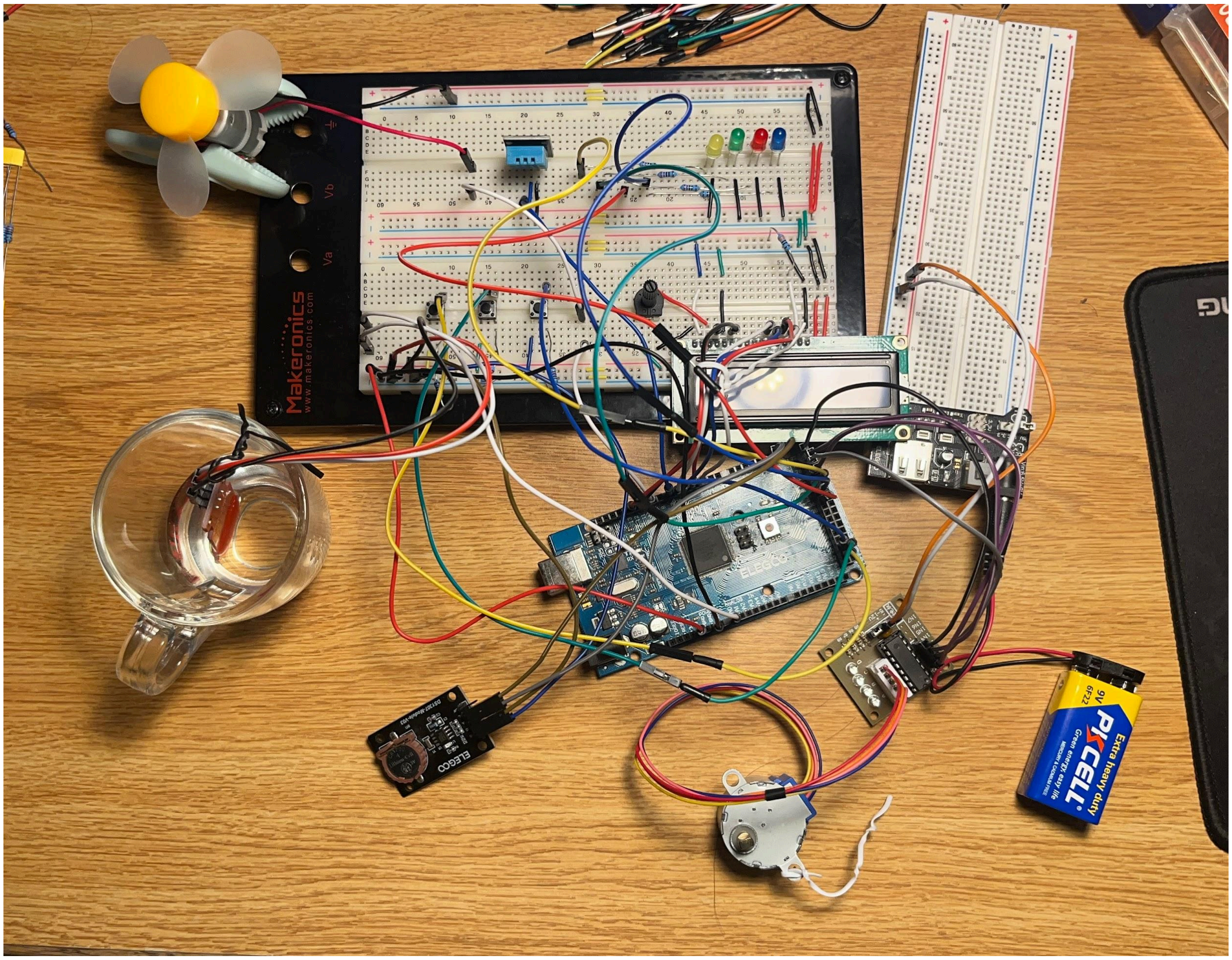
8. LED Indicators (PC1, PC3, PC5, PC7)

- Four LEDs represent system states:
    - Yellow (DISABLED), Green (IDLE), Red (ERROR), Blue (RUNNING).
- Controlled via masked writes to PORTC to avoid interference with other pins.

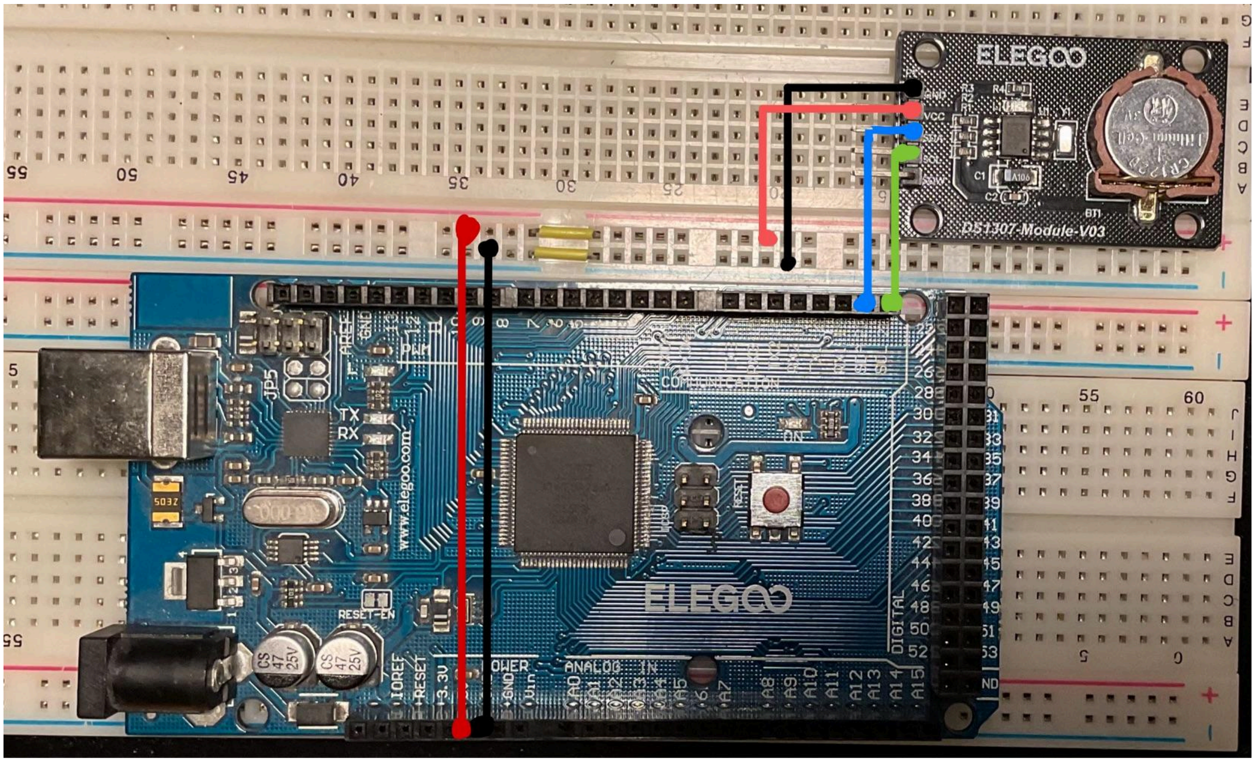
9. Buttons (PB1, PB2, PB3)

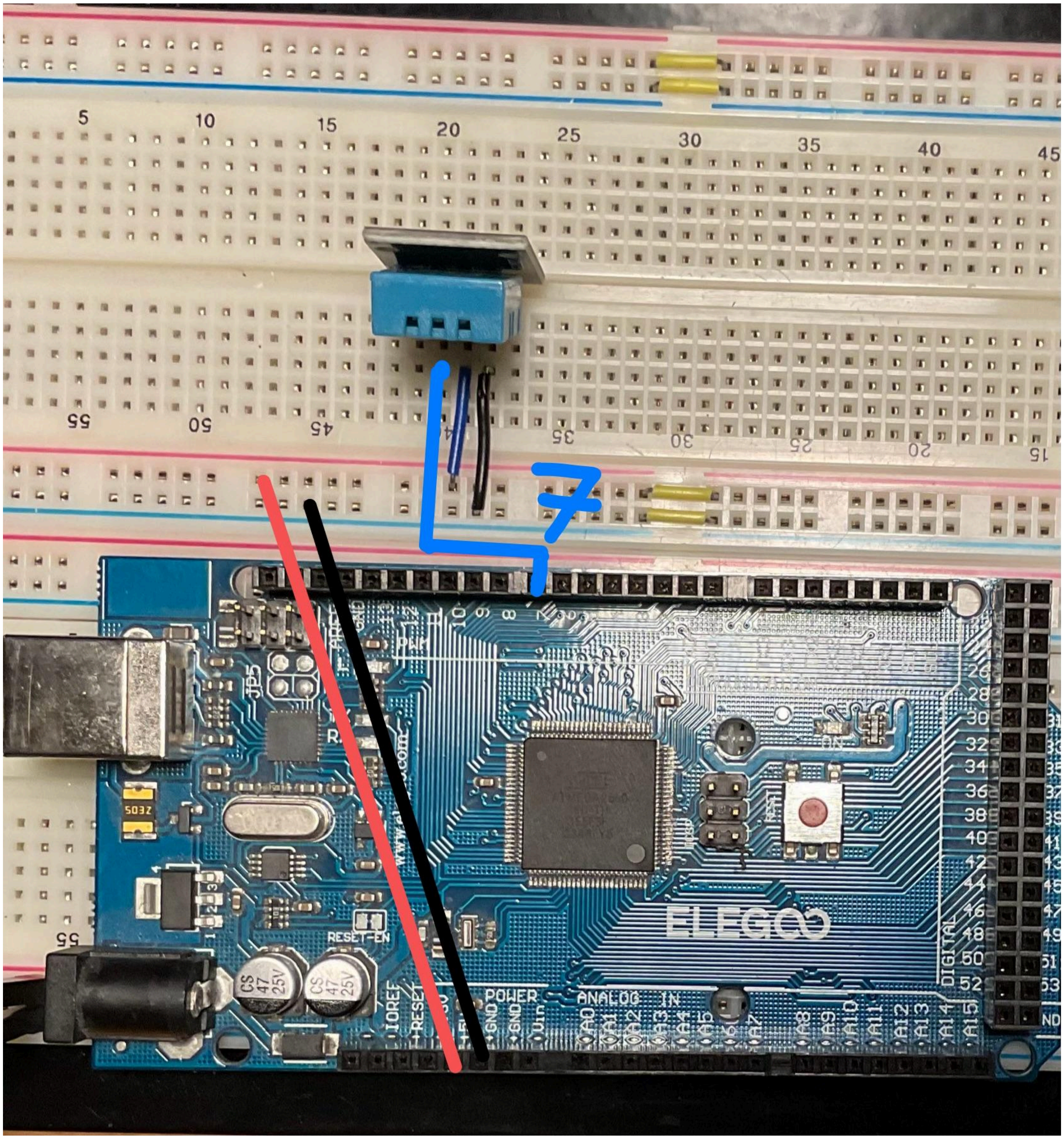
- **Start Button (PB3)**: Enables the system, transitioning from DISABLED to IDLE.
- **Reset Button (PB2)**: Forces system into DISABLED state, turning off fan and sensors.
- **Control Button (PB1)**: Activates the stepper motor to adjust the vent position.

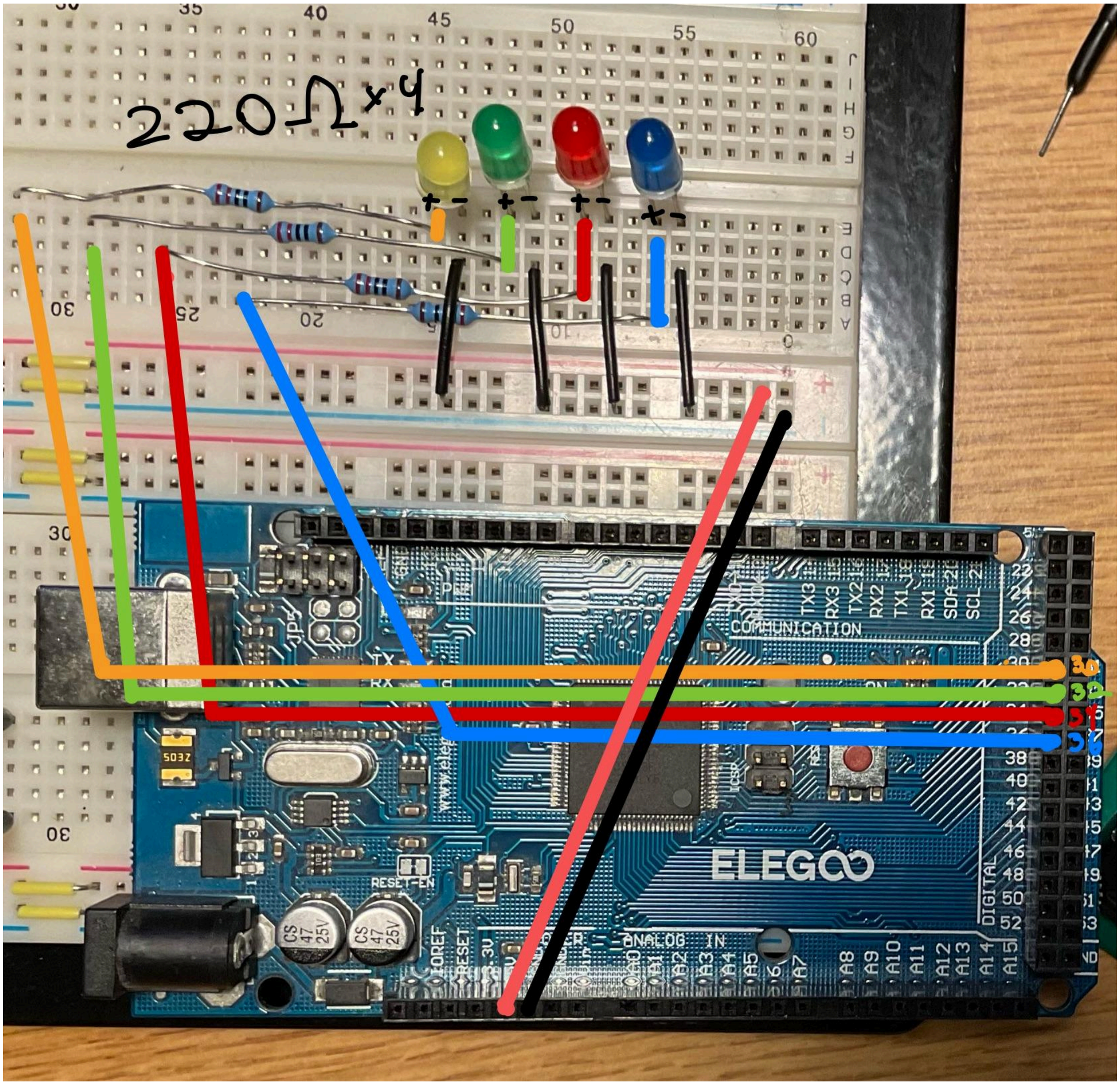
Circuit Image.

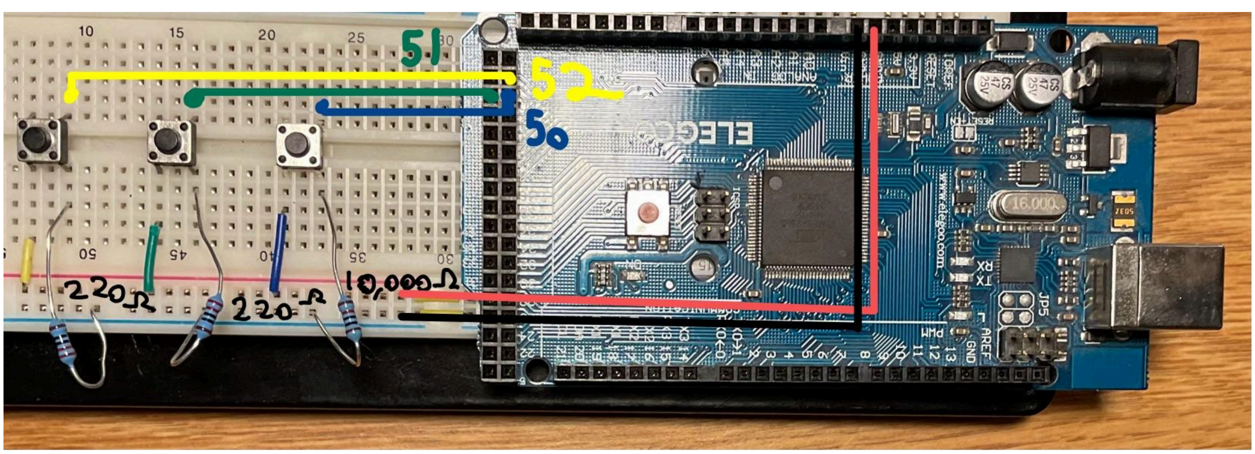


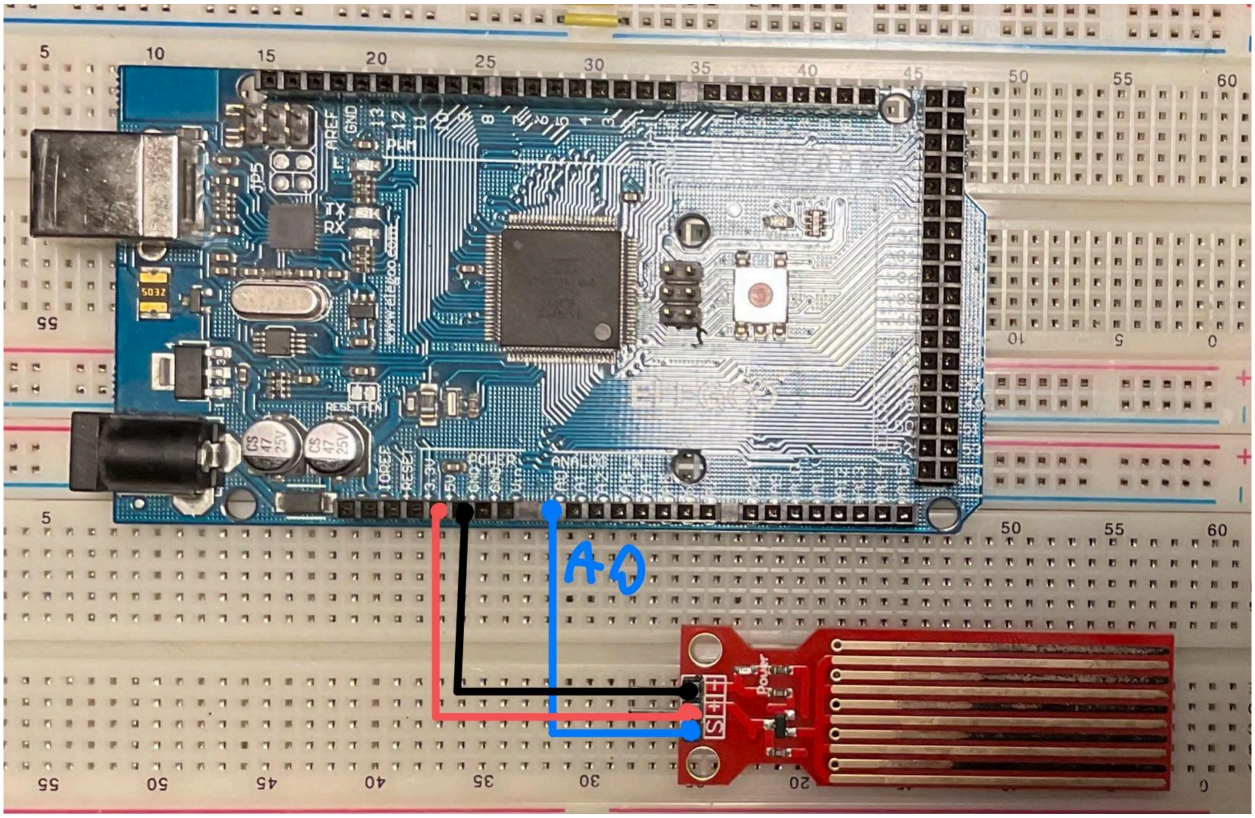
Schematic Diagram

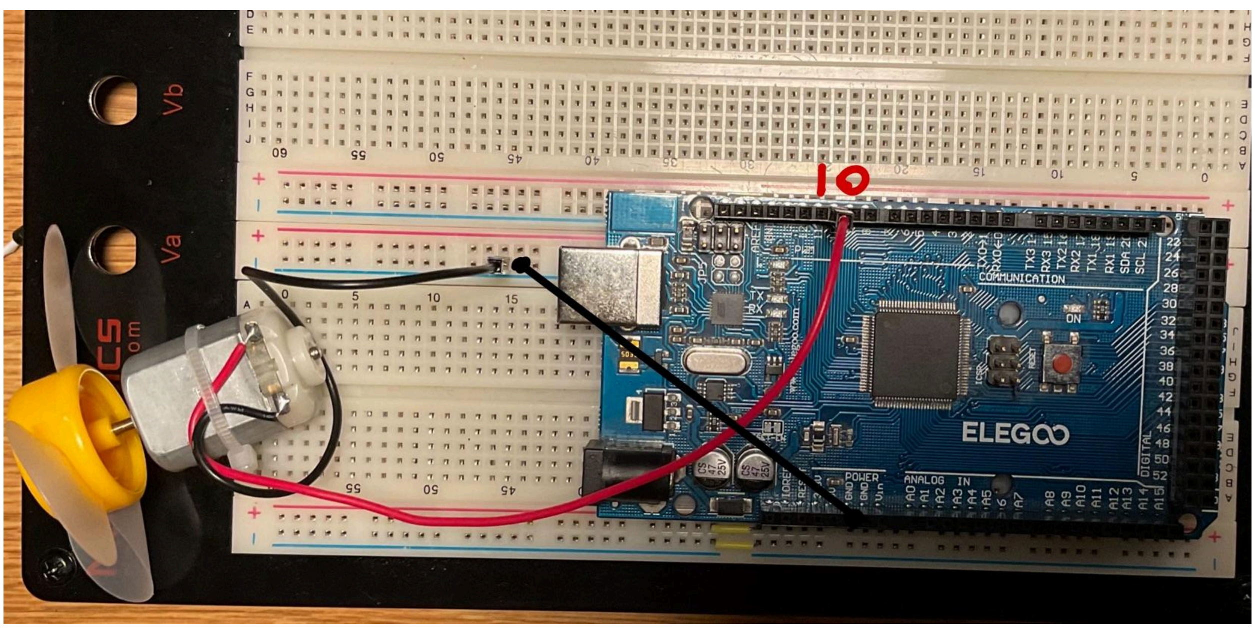

ELEGOO
DS1307-Module-V03
ELEGOO
DIGITAL
COMMUNICATION
POWER
ANALOG IN
www.elegoo.com

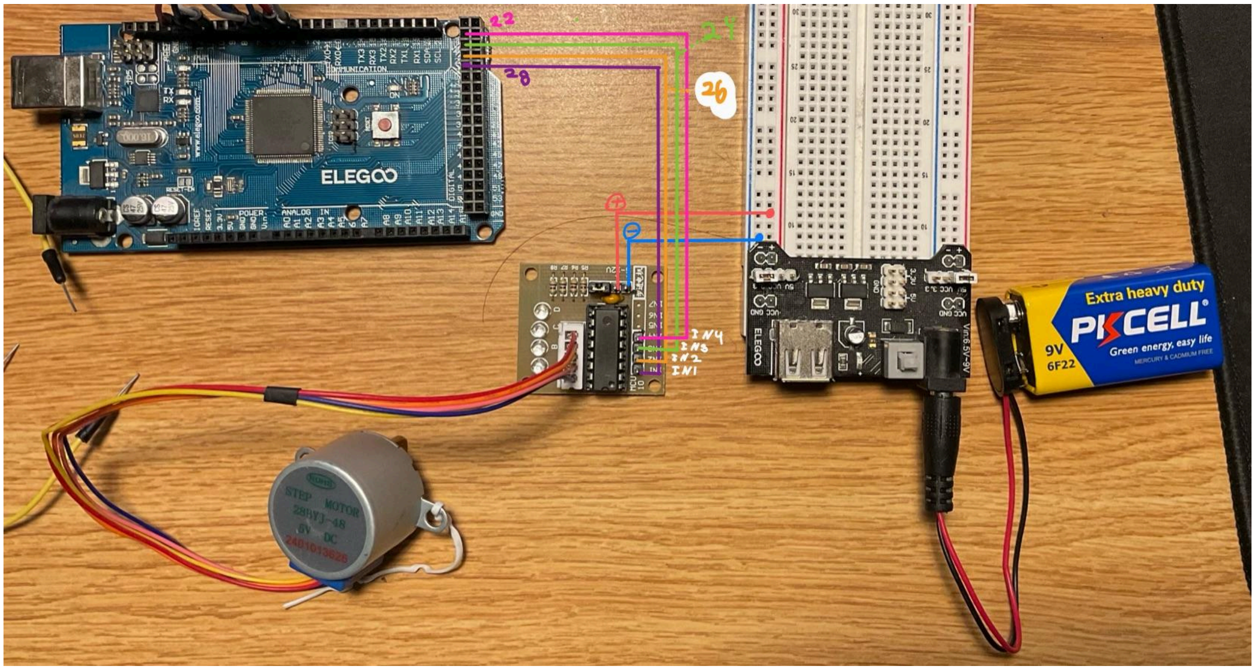

7
ELEGOO
POWER
ANALOG IN
DIGITAL
RESET-EN


220Ω x4
ELEGOO

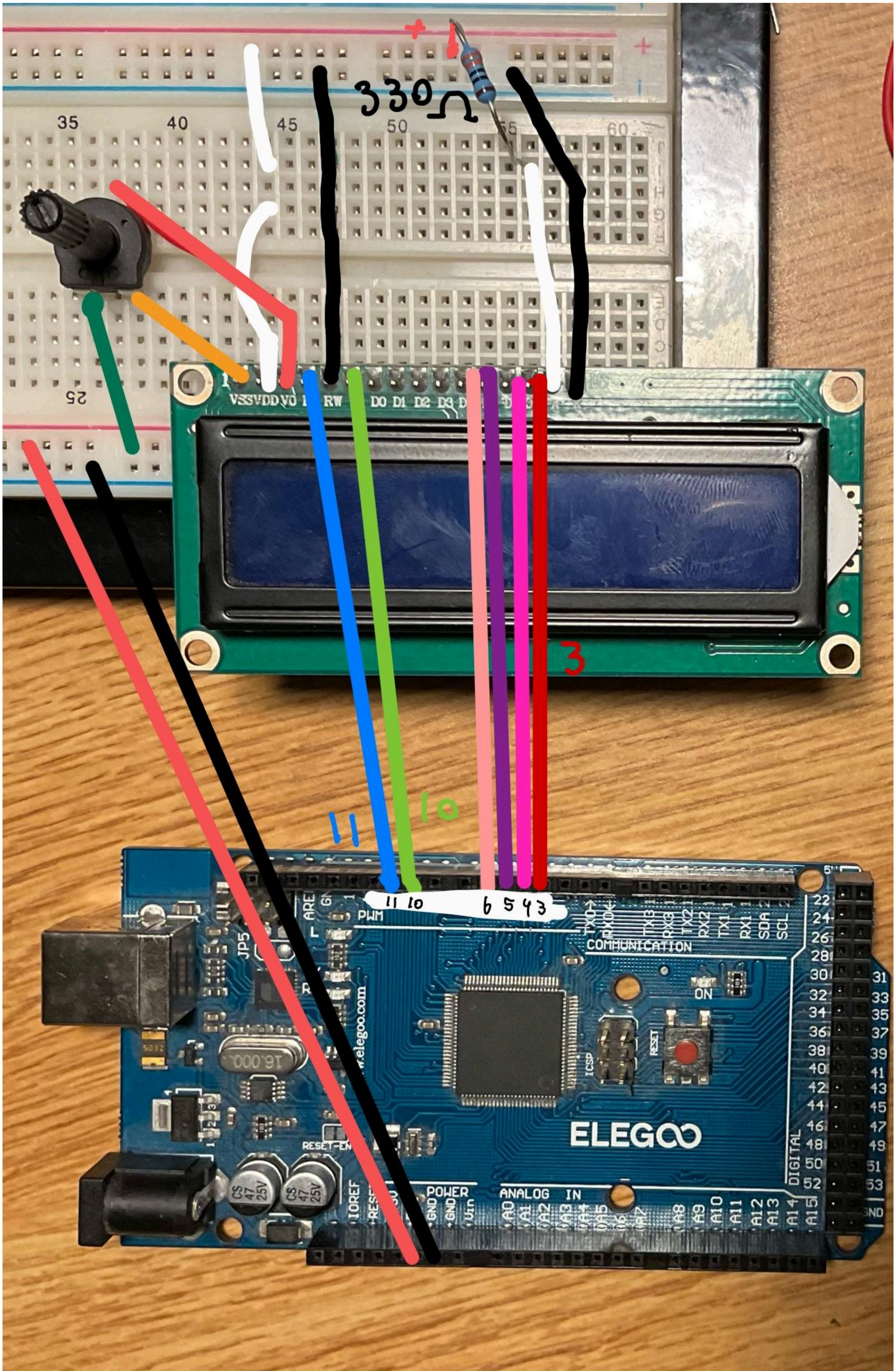

51
52
50
220Ω
220Ω
10,000Ω


A0
ELEGOO


10
ELEGOO
Vb
Va



22
24
26
28
ELEGOO
IN4
IN3
IN2
IN1
Extra heavy duty
PKCELL
9V
6F22
Green energy, easy life
STEP MOTOR



330Ω
11
10
3
11 10 6 5 4 3
ELEGOO

System Demonstration

https://youtu.be/zAGNxGv3r9A?si=ShwIqhiCA-hQKIuW

Environmental Impact

The swamp cooler system was designed with environmental responsibility in mind, striking a balance between energy efficiency, affordability, sustainability, and accessibility. By using evaporative cooling rather than traditional refrigeration, the system consumes significantly less electricity, reducing both operating costs and carbon footprint. It relies on inexpensive, widely available components such as the DHT11 sensor, stepper motor, and cheap LEDs, making the design affordable for students, hobbyists, and people on a budget. Sustainability is addressed through modular construction and repairable parts, ensuring that components can be replaced individually rather than discarding the entire system, which minimizes electronic waste. The relative simplicity allows people to modify the system future, especially the layout of components into housing for the unit. Finally, it's accessible by providing clear LED indicators, a simple LCD interface, and simple button controls, making the cooler easy to operate and maintain even for end users. Furthermore, the system was designed with some safety in mind. It operates on low power, and all exposed wiring is properly wrapped in insulation. The system, in its current form, uses short, non-loose wiring for any connections that don't need to be moved for testing purposes, keeping them out of the way. The system could be more durable by adding housing and tying down components, but the parts are relatively cheap and widely available.