Final Project Report

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1 Project Description:

This project implements an evaporative cooling system (swamp cooler) using the ATmega2560 Microcontroller. It consists of all the components found in teSystem monitors temperature and humidity levels, controls a fan motor based on temperature thresholds, monitors water levels, provides user controls for system operation and vent adjustment, and logs state transitions to a host computer. The implementation uses register-level programming for most functionality, avoiding high-level Arduino functions such as pinMode() and digitalWrite() as specified in the requirements.

2 Component Details:

1. Microcrontroller
   - ATmega2560: The primary controller.
2. Sensors
   - DHT11 Temperature and Humidity Sensor: Connected to the microcontroller to monitor ambient temperature and humidity.The sensor values are read through pins SCL and SDA using serial communications, with data displayed on the LCD during the RUNNING or IDLE state.
   - Water Level Sensor: Used to monitor the reservoir water level. Implemented using direct ADC sampling without the Arduino ADC library. When water levels fall below threshold, the system enters the ERROR state, this ERROR state must then be clear and the sensor value will be reread to determine the machine state.
3. Actuators:
   - GPU Fan: Repurposed for primary air circulation it provides 40cfm at 12VDC, controlled by a separate power supply board to prevent damage to the Arduino and controlled using a SRD-05VDC relay breakout board with optocouplers, flyback diodes and transistors. The fan logic is determined by temperature readings and the current state through direct register manipulation.
   - Stepper Motor: Used to simulate the use of a vent to directionally control the airflow or restrict airflow out of the exhaust. The vent is adjusted using push buttons on the top of the cooler adjustable by the user through a potentiometer. The Arduino stepper library was used to position the stepper motor.
   - Peristaltic Pump: 12V peristaltic pump with .25" vinyl tubing to circulate water through the system. The pump is controlled using a SRD-05VDC relay breakout board with optocouplers, flyback diodes, and transistors.
4. User Interface:
   - LCD Display: Shows current temperature, humidity, during the IDLE or RUNNING state.
   - LEDs: Indicate system status:
     - Yellow LED: Indicates DISABLED state

  - Green LED: Indicates IDLE state
  - Blue LED: Indicates RUNNING state
  - Red LED: Indicates ERROR state
- Control Button: Performs 3 distinct operations depending on system state using ISR()
  - DISABLED -¿ IDLE if no errors exist.
  - RUNNING -¿ DISABLED turns off fan and pump.
  - ERROR -¿ IDLE/RUNNING user must hold button for 3 seconds to clear error.

5. Additional Components
   - Peristaltic Pump: Circulates water through the system
   - Relays: Control power to the fan and water pump.
   - Evaporative Cooling Pads: Provide the wet surface for air evaporation cooling.
   - File Cabinet Box: Housing.
   - 12V GPU Blower Fan: Circulate air through the housing.
   - Capacitors: Various capacitor values were implemented to eliminate the need for debouncing logic in the code. Also used to damped initial voltage drop that may be seen from the power supply to the buck converter when transition to RUNNING state.
   - 19V-¿5V 2A Buck Converter: Converter to step down a regulated voltage from 12VDC to 5VDC.

3 System Overview:

The swamp cooler operates as a finite state machine (FSM) with four distinct states, each representing a specific mode of operation based on environmental conditions and user input. As a control system, the FSM enables the cooler to transition logically and predictably between these states, ensuring efficient performance and responsiveness. These states include:

1. DISABLED state:
   - Yellow LED on
   - No temperature or water level monitoring
   - System responds only to the Start button (via ISR)
   - Vent control disabled
2. IDLE state:
   - Green LED on
   - Continuous temperature, humidity, and water level monitoring
   - Fan motor off
   - Transitions to RUNNING state when the temperature exceeds the threshold
   - Transitions to ERROR state if the water level is too low
   - Transitions to DISABLED if the stop button is pressed
   - Vent position adjustable
3. RUNNING State:
   - Blue LED on
   - Fan motor on
   - Continuous monitoring of temperature, humidity, and water level
   - Transitions to IDLE state when the temperature falls below the threshold
   - Transitions to ERROR state if the water level is too low

- Transitions to DISABLED if the stop button is pressed
- Vent position adjustable

4. ERROR State:

- Red LED on
- Fan motor off
- Error message displayed on LCD (”Water level is too low”)
- Transitions to IDLE if the reset button is held for 3 seconds and the water level is sufficient

4 Links

- Demonstration Link
- Repository Link

5 Circuit Images/Schematic Diagram:

This section presents visual representations of the swamp cooler circuit, including both the physical hardware and its electrical design. The images help illustrate the component layout and the circuit’s operational flow, providing a clearer understanding of the system’s structure and functionality. These visuals serve as a complement to the technical descriptions provided in earlier sections.

Figure 1: The circuit in its entirety.

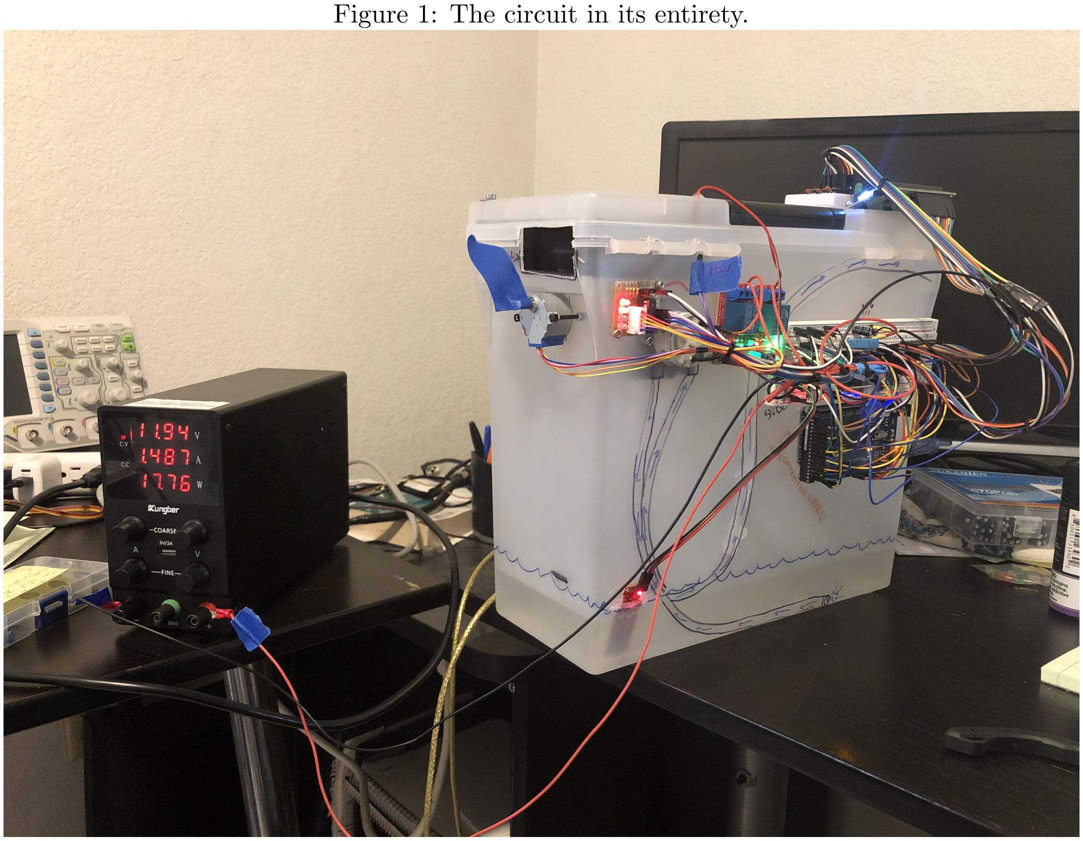

Figure 2: The control part of the circuit.

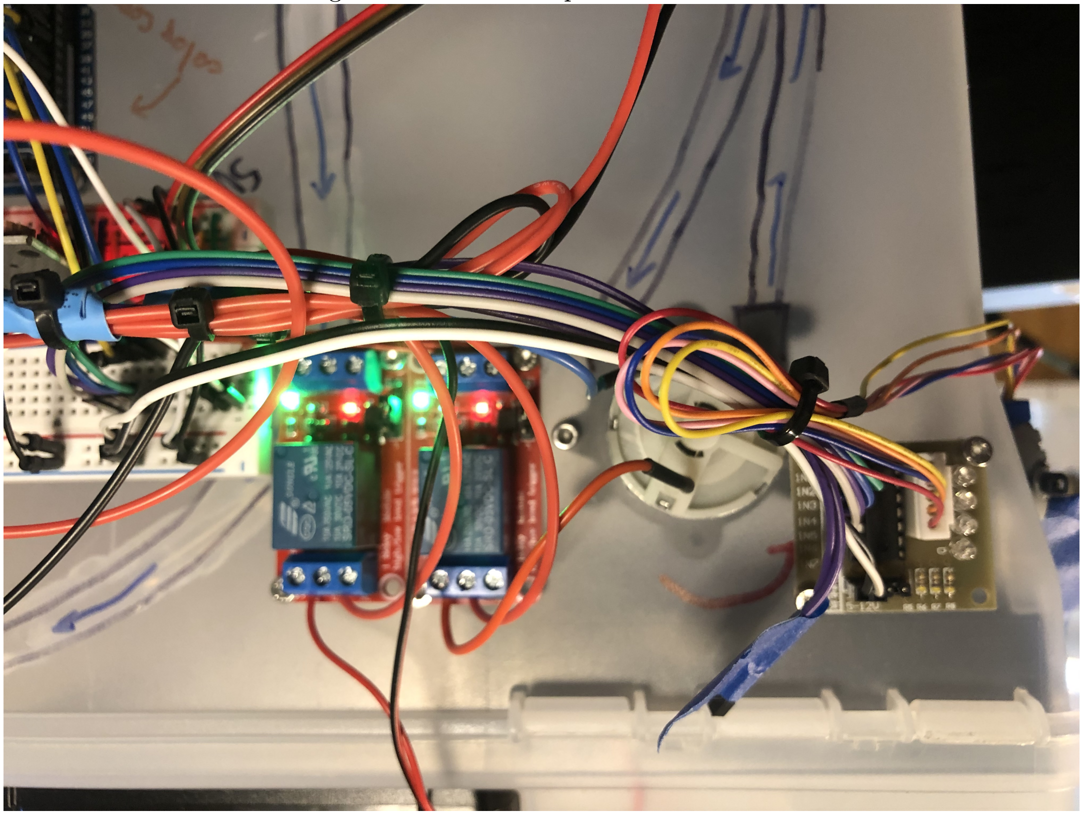

Figure 3: The I/O part of the circuit.

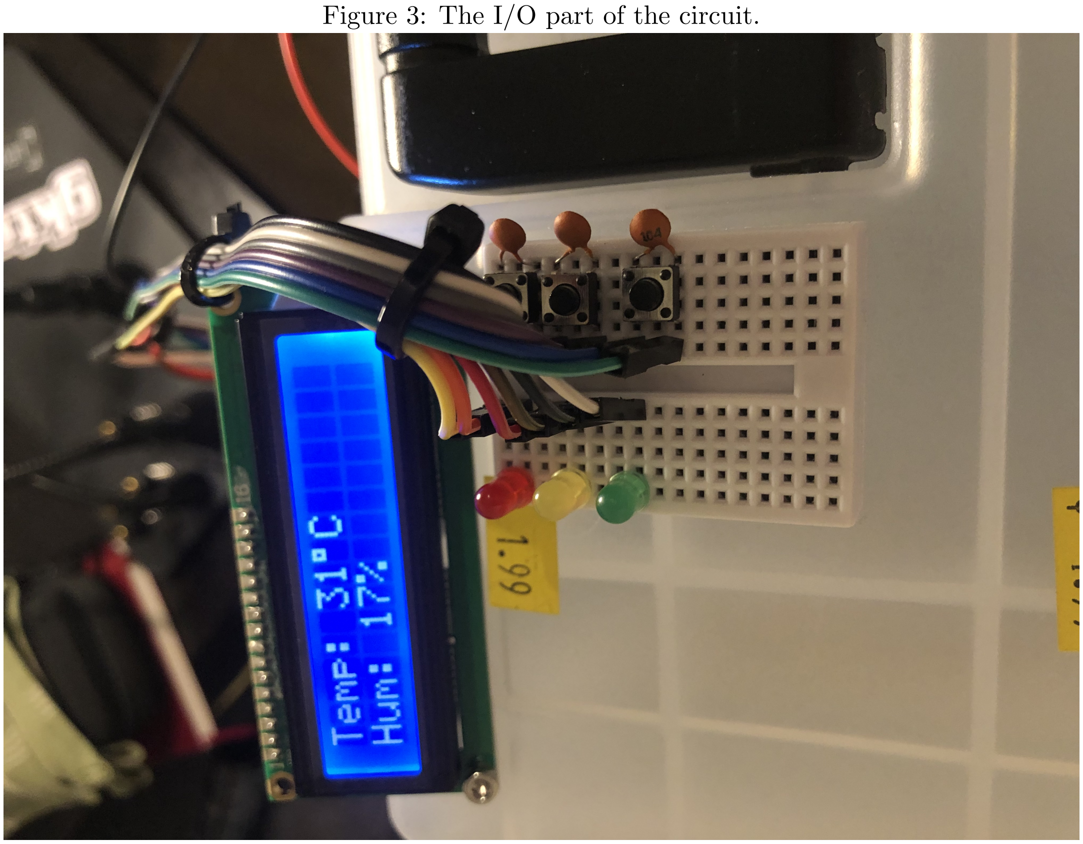

Figure 4: The logic part of the circuit.

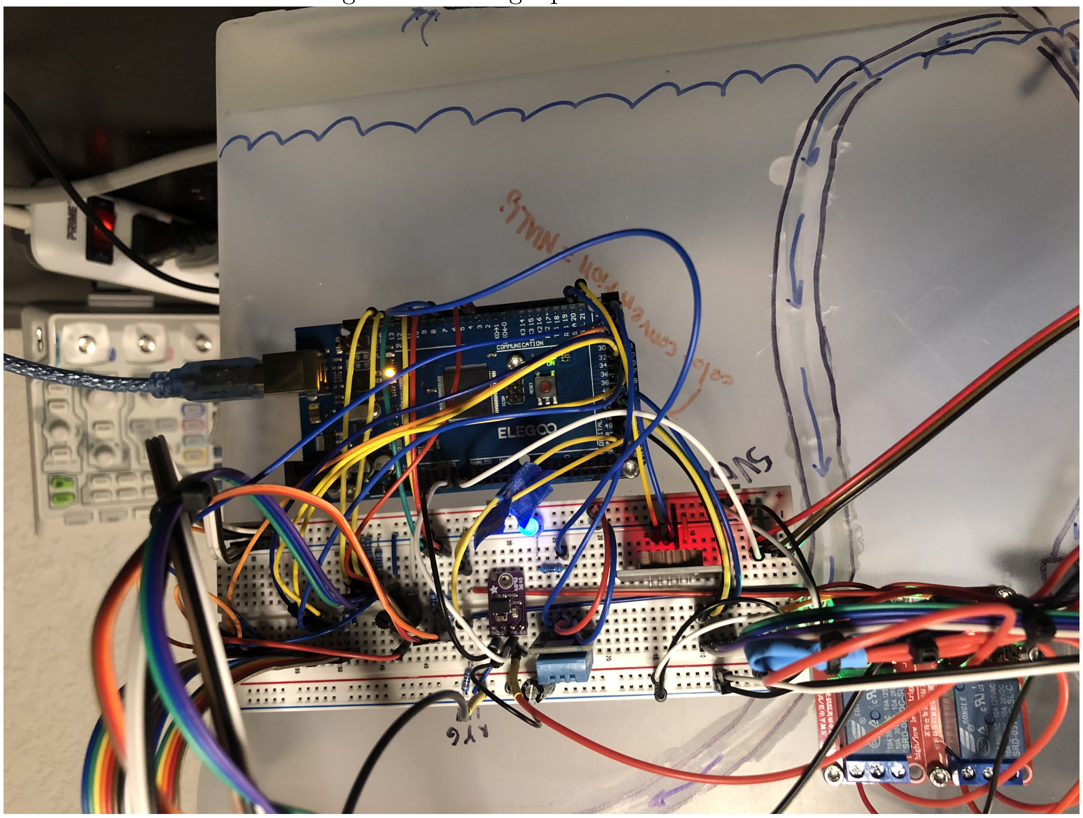

Figure 5: Schematic diagram of the cooler's circuit.