Requirements Specification for EELE465 Lab Project 6: Thermoelectric temperature control

Academic Dishonesty Clause: It is expected that you, along with your partner, write this code uniquely for this project during this semester. It is acceptable to use code YOU have previously written as examples and guides. It is not acceptable to copy/paste code written by other individuals nor by you during previous semesters or for other classes.

Lab project goal: Control the temperature of a "plant" using a thermoelectric device

The master will have three modes of operation based on the user's selection on the keypad; heat-only, cool-only, temperature-matching. During heat- or cool-only modes, the plant's Peltier Device will be sent into one of the two modes. During temperature-matching mode, the master will attempt to maintain the plant at the same temperature as the "ambient" temperature. The master processor will received the mode selection using the keypad and directly control the Peltier/thermoelectric device based on these modes; it will also collect time data from an RTC.

Slave processors will drive an LCD and an LED lightbar, respectively. The LCD will display both the plant and ambient temperature, as well as the duration of time which the controller has been operating in the present state. The LED lightbar will indicate whether the system is actively heating, cooling, or maintaining.

The temperature data reported on the LCD will be the moving-window average of a user-specified size.

Outcomes:

After this lab you should be able to:

- Produce a feedback control loop using a microcontroller.
- Control a Peltier Device.

Background:

A Peltier Device is an easy to control thermoelectric device. Start this lab by performing a literature review on Peltier Devices. You will need at least one reference on how Peltier Devices work include within your project documentation.

The following requirements section is again broken into Requirements (numbers) and Specifications (letters). The rubric for this project is more detailed than past rubrics due to the fact this project is weighted much heavier than pervious projects. Please pay close attention to the rubric before scheduling your formal demo.

Acknowledgements: Randy Larimer

Requirements for lab project completion:
At the end of this project, your embedded system must do the following:

1. Collect the ambient temperature using the LM19 analog temperature sensor
    a. Collect data at least every 1s (goal is every 0.5s)
    b. Project Stretch: Collect temperature data within 1 degree of actual temperature (proof is required).

2. Collect the plant's temperature using the LM92 I2C temperature sensor
    a. Collect data at least every 1s (goal is every 0.5s)
    b. Project Stretch: Collect temperature data within 1 degree of actual temperature (proof is required).

3. Collect the time of the present mode-of-operation using an I2C RTC.
    a. Collect data at least every 1s (goal is every 1s)
    b. Project Stretch: Time starts over at 0s within 0.5s of button press (proof is required).

4. Produce a moving-window average of the temperature
    a. The average of both temperatures should use the same number of samples
    b. Proj Stretch: Allow the user to select the size of the window using the Keypad

5. Control the Peltier Device's modes of operation using the keypad
    a. When "A" is pressed, configure Peltier Device to heat
    b. When "B" is pressed, configure Peltier Device to cool
    c. When "C" is pressed, configure Peltier Device to match ambient temperature
    d. When "D" is pressed, turn Peltier Device off
    e. Turn the Device off, regardless of the selected mode, after 5 minutes (300s)
    f. Proj Stretch: Allow user to override the ambient temperature with the Keypad and have the system match that desired temperature.

6. Display information on the LCD
    a. Display the temperatures in °Celsius ±0.1°C and refresh every 2s at least
    b. Display the time of operation in seconds ±1s and refresh every 1s at least
    c. Display the user's new selection of N within 0.5s of the button being pressed.

Ideally, your display will look something like this:

Col / Row	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
1	R	e	s	=	N				A	:	X	X	.	X	°	C
4	M	:	T	T	T	s			P	:	X	X	.	X	°	C

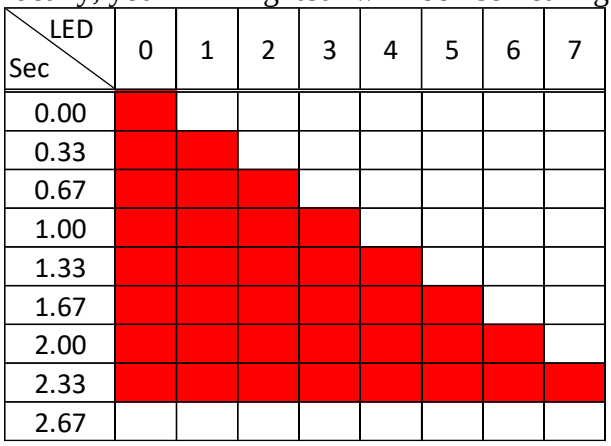
Where:

"Res" is the N number of samples in the user's requested average
"M" is the mode of operation (A, B, C, or D)
"T" is the number of seconds
"A" is the Ambient Temperature with XX.X°C of resolution
"P" is the Plant Temperature with XX.X°C of resolution

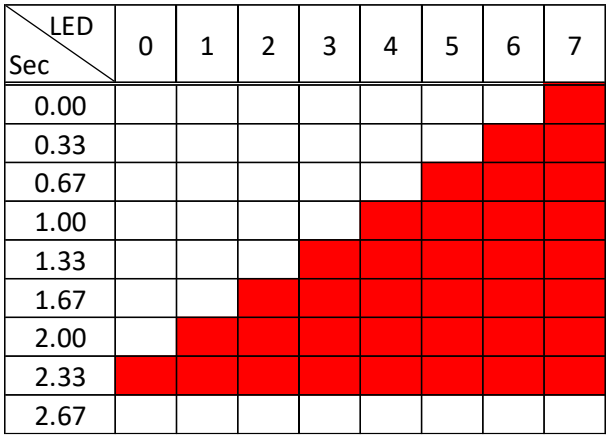
Acknowledgements: Randy Larimer

7. Display the heating/cooling status on the LED lightbar
    a. When actively heating in mode A or C the lights should scroll up one light per 1/3s
    b. When actively cooling in mode B or C the lights should scroll down once per 1/3s
    c. When not actively heating or cooling in mode D or after 5min the lights should flash once per 1/3s
    d. Proj Stretch: Implement a similar, but slightly different pattern for heating when in mode A vs mode C. Do the same thing for the two cooling states.

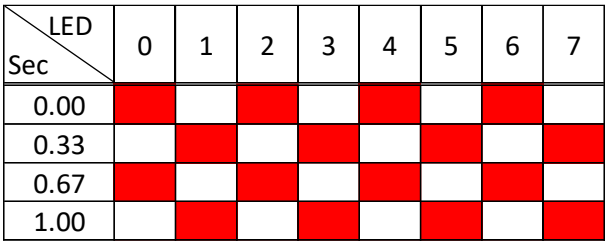
Ideally, your LED lightbar will look something like this:



Example of scrolling up indicating heating mode



Example of scrolling down indicating cooling mode



Example of flashing indicating no heating/cooling

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Assessment for project completion:
Your project grade will be based on the demonstration (30pts) and presentation/documentation (5pts) of your project. Recall: according to the syllabus, you must score better than 70% on this project to pass the class.

Note: all requested evidence may be pre-recorded rather than demonstrated in live-time.

Your **Code Demonstration** must (see PDF versions of rubric for grading details):

- Include a clear introduction
    - Do show your circuit diagram and how it relates to the hardware
    - Do NOT show your flowchart at this time (in the interest of time)

- Demonstrate that the LM19 is collecting ambient temperature data
    - Show evidence of the timing (+1pt if timing is at 0.5s)
    - If you calibrated your data somehow, wait to show evidence of that until the end

- Demonstrate that the LM92 is collecting plant temperature data
    - Show evidence of the timing (+1pt if timing is at 0.5s)
    - If you calibrated your data somehow, wait to show evidence of that until the end

- Demonstrate that the RTC is collecting timing data
    - Show evidence of the timing (+1pt if timing is at 1s)
    - If your time starts over within 0.5s of switching modes, wait to show evidence

- Demonstrate that both temperature datasets are averaged
    - Inform the instructor what the moving average window is defaulted to
    - Show evidence that averaged-value is correct (+1pt)
    - If the user is able to adjust window, wait to demonstrate this until the end

- Demonstrate that the system is able to provide basic signals to Peltier Device.
    - Select A and allow instructor to feel the system heat
    - Select B and allow instructor to feel the system cool
    - Select D and provide evidence that system is off

- Demonstrate that the system is able to operate in a feedback loop.
    - Select C and show that the plant's temperature tracks the ambient temperature
    - Once the two temperatures match, use your finger to heat up the ambient sensor, show that the plant attempts to track that heating.

- Demonstrate the timing (if collected) for the LCD and LED
    - You have certainly shown the LCD and LED working by now, at this point just show any timing evidence that the outputs update correctly.

- IF you have attempted any of the project stretch goals
    - Provide evidence that the ambient and/or plant's temperature is accurate
    - Provide evidence the time displayed on the LCD restarts at 0s withing 0.5s of a new button press
    - Demonstrate that the user can use the keypad to change the averaging-window size
    - Provide evidence that the user can override the ambient temperature with the keypad
    - Address any other project stretch goals you attempted

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