MCE380: Measurements and Instrumentation Lab

Laboratory Session
Response of First and Second Order Systems

This lab contains two separate activities. In one of them, a Resistance Temperature Detector (RTD) and signal conditioning unit will be calibrated with boiling water and an ice bath. Then, the step response of the RTD will be recorded and the time constant will be calculated. In the second activity, groups will capture the response of an analog meter using a video camera. The overshoot, settling time, natural frequency and damping ratio will be obtained from the video.

1 RTD Calibration and Response

The RTD probe and signal conditioner have been mounted on a support post that allows immersion in either hot or cold water. Observe the following safety precautions:

1. Do not touch the AC power cord.
2. While one student manipulates the probe and the hot water bucket, the rest stays at a safe distance (only a one pair of hands in a three feet radius from the experiment)
3. Do not touch the water bucket or the top surface of the hot plate.
4. Do not cause any water to splash.

1.1 Procedure

You will first adjust the signal conditioner to give standardized voltages at freezing and boiling. Then you will use a LabJack USB Data Acquisition interface (DAQ) to capture the step response of the system when transferring the probe from ambient to boiling water, from boiling water to ice water and from ambient to ice water.

1. Fill the water container, place it on top of the hot plate and turn the plate on at the maximum setting. Then adjust the temperature for a steady boil without wasting the water away too soon.
2. Have a 16oz cup ready and full of ice with a little added water (there must be no air surrounding the probe upon immersion).
3. Plug in the signal conditioning unit. Immerse the RTD in the ice and read the voltage using the multimeter. You must wait until the reading stops changing.. This step is to verify that the system is working.
4. Read the span and offset adjustment procedure in the signal conditioner instruction booklet. Once the water boils, perform the adjustments so that 0C=32F gives zero volts and 100C=212F gives 10 volts.
5. Wipe the RTD probe clean and measure the voltage after letting the probe stabilize in air. Write this number down and convert it to temperature. Check with the rooms actual ambient temperature.

6. The terminals of the LabJack DAQ have been already connected to the OUTPUT of the signal conditioner. If there are doubts, please ask.

7. Examine the `RTD_acquire` program in Matlab and run it for a minute or so with the probe on air.

8. Adjust the program as you see fit so that the following step responses are recorded: ambient to boiling, boiling to ice, ambient to ice. You need to adjust both the total number of points and the sampling interval, which indirectly adjusts the total recorded time. You may need to try a couple of times until you get a sense of the time constants involved. Rename variables between runs and then save the whole data set to a *.mat file. Check that the file was properly stored (clear and reload).

2 Second-Order Reponse

You will take a video shot of the needle displacement as the power switch is flipped. It is recommended to place a stopwatch next to the needle to have an accurate time measurement. Later, using any video player, stop the video as often as possible and record the time and voltage.
Report Requirements:

1. Describe the two experiments that were conducted, including equipment used, brief explanation of the procedure and what data was collected. Be sure to include the key parameters: how often were points taken and for how long, etc.

2. What are the sensitivities of the RTD system and the thermocouple system?

3. Show nice plots of the temperature transition curves, in terms of degrees Celsius, not volts.

4. Find the time constant of the RTD system and the thermocouple system from the transition curve. Do you get consistent values?

5. Show a plot of needle displacement against time from the video capture. Explain the steps taken. Find the damping ratio ζ and the natural frequency w_n of the analog voltage meter by analyzing the video, as directed by the instructor.

Report:
Write a high-quality technical report. Don't fall for sloppiness, spelling mistakes and poor graphics. A well-written account of a failed experiment is better than a poorly-written report about a successful experiment.
DATE DUE: 3 class times after the lab session. Example: if the lab was completed on a Tuesday, the report is due the Thursday of the following week.