Insulating Properties of Common Liquid Containers

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ME 240 - Professor Cottrell

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Project Description

The goal of this project is to determine the best way to keep a water-based beverage such as a soda or a beer cool for the longest time. We hoped to accomplish this goal by tracking the temperature of several beverage containers filled with water over time. We made use of multiple DAQ boards all with their own AD 592 transducer, as well as a LabVIEW program created earlier in the semester to accomplish our goal.

Procedure and Calibration

To set up this experiment we had to complete several steps. First, we determined the most common containers people drink out of. After some brief brainstorming we decided that the four most common contexts for beverage drinking are out of a can, out of a glass, out of a plastic "solo" cup, or out of a can kept in an insulating sleeve or "koozie." After this we decided that the most consistent test fluid would be water so we refrigerated a large pitcher of water, for a long period of time to ensure all the water had reached an equilibrium temperature with the refrigerator. To keep the volume or amount of water consistent, we filled clean empty aluminum cans with the cold water before putting them in their designated test containers. Once everything was filled, and our circuits and DAQ boards were wired up, we opened multiple LabVIEW programs. We decided that the easiest way to do the experiment while ensuring some form of accuracy was to use our pre-existing AD 592 homework program. Once we had selected all of our devices and set up the programs properly, we had to calibrate our circuits. We used the same procedure as we did in the homework to do our calibration. We let room thermometer reach equilibrium with the surrounding and adjusted our potentiometers until we got our AD 592's to show the same temperatures as the room thermometer. This simple calibration was good enough to accomplish our goals since we were going for a comparison of 4 different data sets and if all of our transducers were working the same it didn't matter if the number was exactly correct. Once all of our DAQ boards were measuring the same, we dipped the tip of each of our AD 592s into the water in each of our containers and ran the LabVIEW programs writing each set of data to different text files. After a few hours we checked all the LabVIEW programs and found that the temperature wasn't changing because the liquid had reached equilibrium with the room. We then ended the experiment and began to evaluate our data. A image of the DAQ circuit diagram is included in the Appendix.

DAQ Structure

Our data acquisition structure was simple. We used our AD 592 program from earlier in the semester with the only modification of taking data samples every 10 seconds (10,000 milliseconds). This is all we can really say about this since there is no way to glorify our data acquisition program, and we used no different configurations. VI documentation is presented later in this lab.

Analysis of Results

The results are graphically displayed in Figures 1-4. All tests were run until the temperature of the liquid approached room temperature.

The can proved to be the second best insulating container. It took approximately 195 minutes for the liquid temperature to approach room temperature.

The can with a koozie was the best insulating container. While it took approximately the same amount of time for the koozie to approach room temperature as it did the can, its starting temperature was higher because it was insulated during the cooling process. This is why the koozie is rated higher.

The glass with water in it was the third best insulating container, but was almost comparable to the can and koozie covered can. It took approximately 180 minutes for the glass to reach room temperature, which is 15 minutes sooner than both can samples. The glass was approximately 1/8" thick.

The final sample was a solo cup. This was by far the worst insulating sample. It only took 90 minutes for the solo cup to approach room temperature. This is half as long as any of the other samples. This could be attributed to the fact that even though plastic is an insulating material, the material of a solo cup is thin, and therefore its insulating properties were minimal.

There are several variables that must be looked at when examining the results of the experiment. The first is the material type. In most instances, containers that are made of insulating materials are going to perform better than ones made of conductive materials (assuming thickness and exposed surface area are comparable). Since glass is a ceramic, it's the best insulating material and the can without the koozie is the worst.

 The next variable that must considered is the material thickness, obviously the thicker the material, the greater the insulating properties. All of the materials were of similar thickness with the exception of the glass, which is significantly thicker than the other materials.

Finally, the last factor that must be considered is the exposed surface area of the containers. Obviously this will affect the rate of heat transfer to the fluid since this portion has no insulation. The solo cup had the greatest exposed surface area, followed closely by the glass. The cans had the smallest exposed surface area.
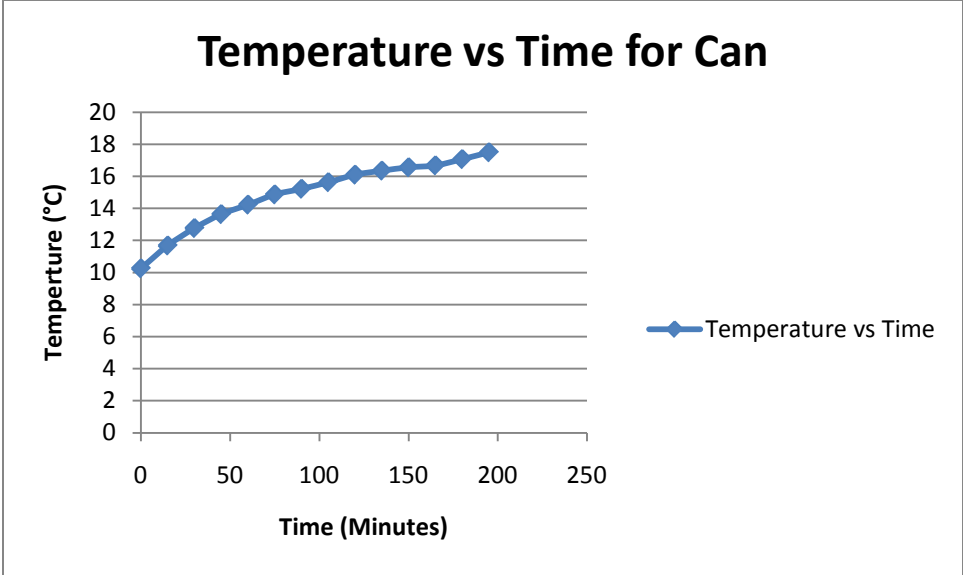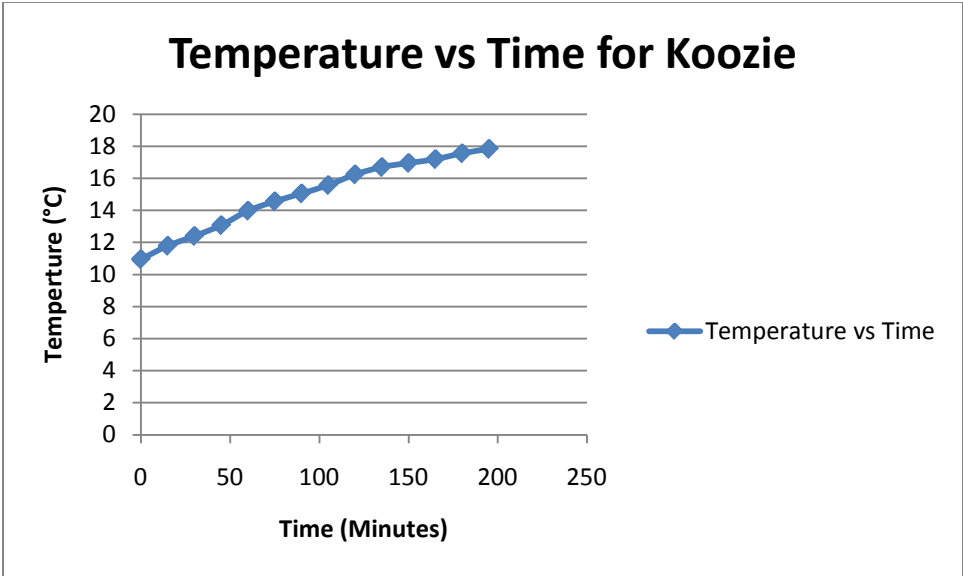
Figure 1 – Temperature vs. Time for Can

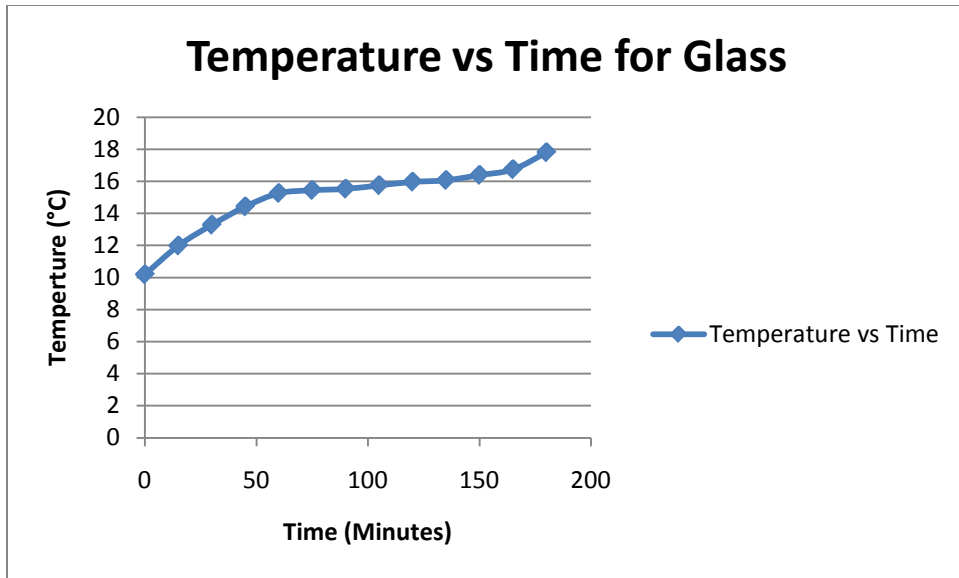Figure 2 – Temperature vs. Time for Koozie

Temperature vs Time for Glass

Figure 3 – Temperature vs. Time for Glass

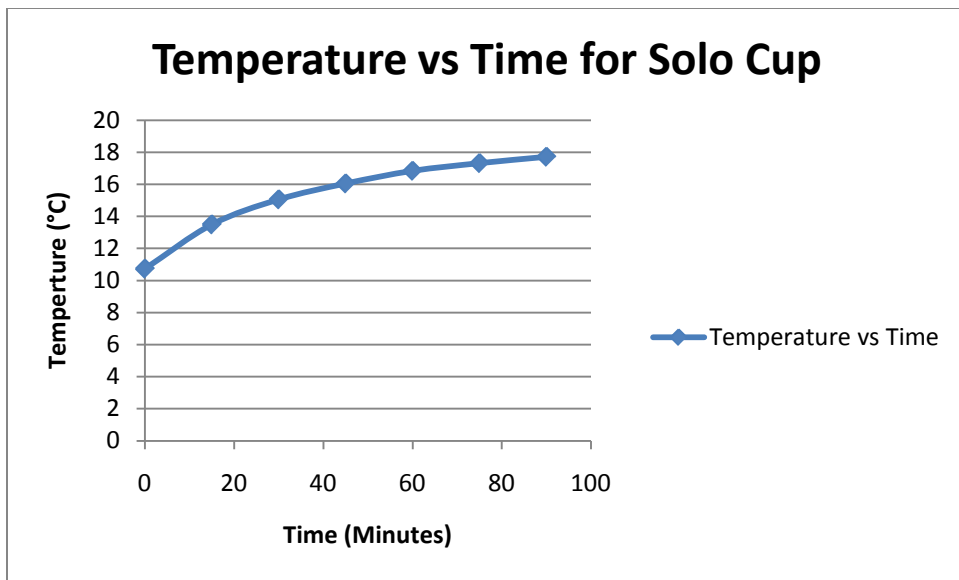**Temperature vs Time for Solo Cup**

Figure 4 – Temperature vs. Time for Solo Cup

Error Analysis

Any errors in the data gathered can be attributed to a variety of different factors. The first being poor calibration of equipment. However, because we have calibrated the equipment before, we don't anticipate this being a problem of much concern (no more than ±0.1°C). The second source for error comes from the legs of the AD592 getting wet. This causes dramatic errors in temperature reading. For example, the temperature will read 400+ °C if the legs of sensor are wet. Again, we don't anticipate this causing any problems in the data we gathered since the magnitude of the error was so large we could detect it before we saved it. The final source of error that could cause problems in our analysis is the

location of the containers in the fridge could affect the temperature, although the fridge was small enough this should be negligible.

Conclusions

The results of the experiment were predictable based on past experiences. The experiment is applicable to many real life situations such as family barbeques and baseball games. One factor the experiment didn't take into consideration was the fact that your hand will act as a heater in real world applications. I expect that in this type of a scenario the can with a koozie and glass would perform comparably better than the other two containers because of their insulating materials and material thickness.

Transducer Conclusions

The transducer seemed to do the job well, as long as it didn't get wet. If the experiment was to be repeated, I would recommend a transducer that can tolerate water. This will allow the transducer to be submerged in water, which will give a more accurate reading of the fluid temperature, rather than just the surface temperature.

Recommendations

If the experiment was to be performed again, it would be recommended that the transducer be submerged in the liquid. I would also try starting the liquid testing at a lower temperature to see analyze the magnitude of the initial change, since most people aren't going to hold onto a soda can for more than 20 minutes before finishing it. It might also be useful to test a glass bottle.

Appendix

- Figure 6 – Example of setup
- Figure 7 – Circuit diagram of DAQ system
- Figure 8 – Program Screenshot
- Raw tabular data of solo cup
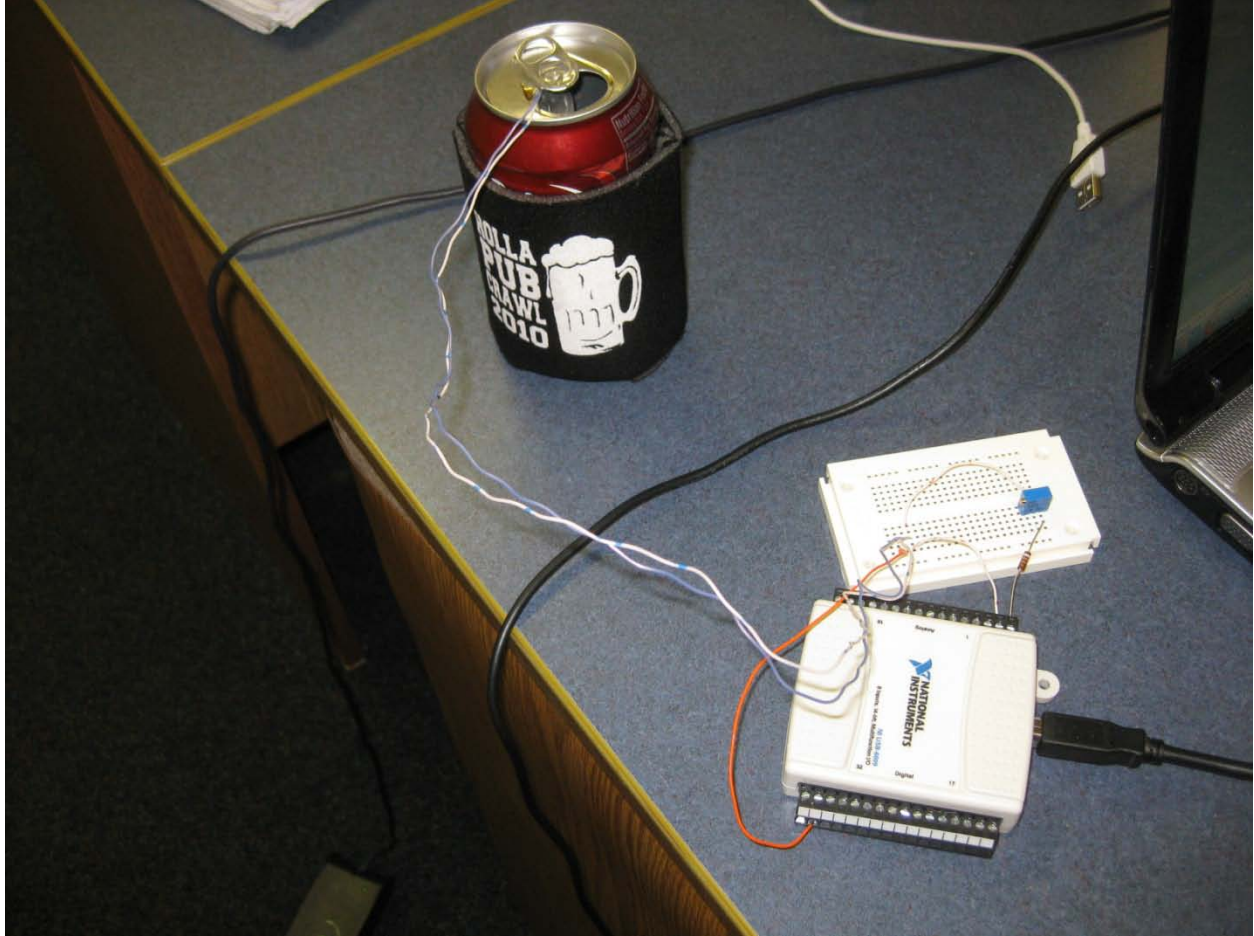- VI Documentation

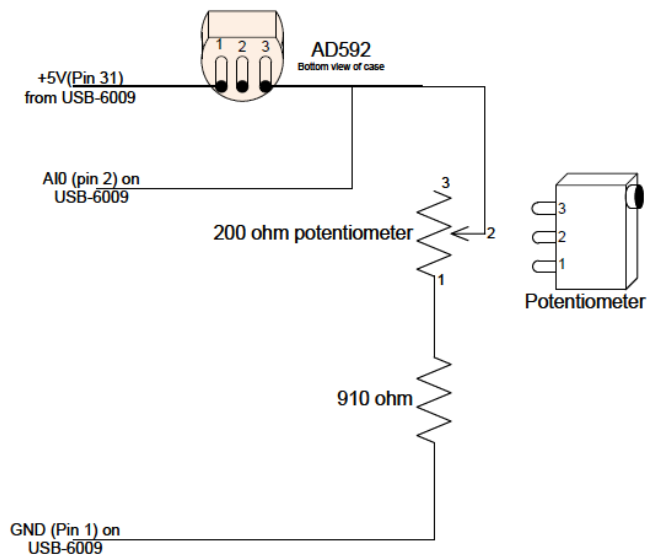# Appendix – Attachments

Figure 6 – Example of Setup

Figure 7 – Circuit Diagram of DAQ System
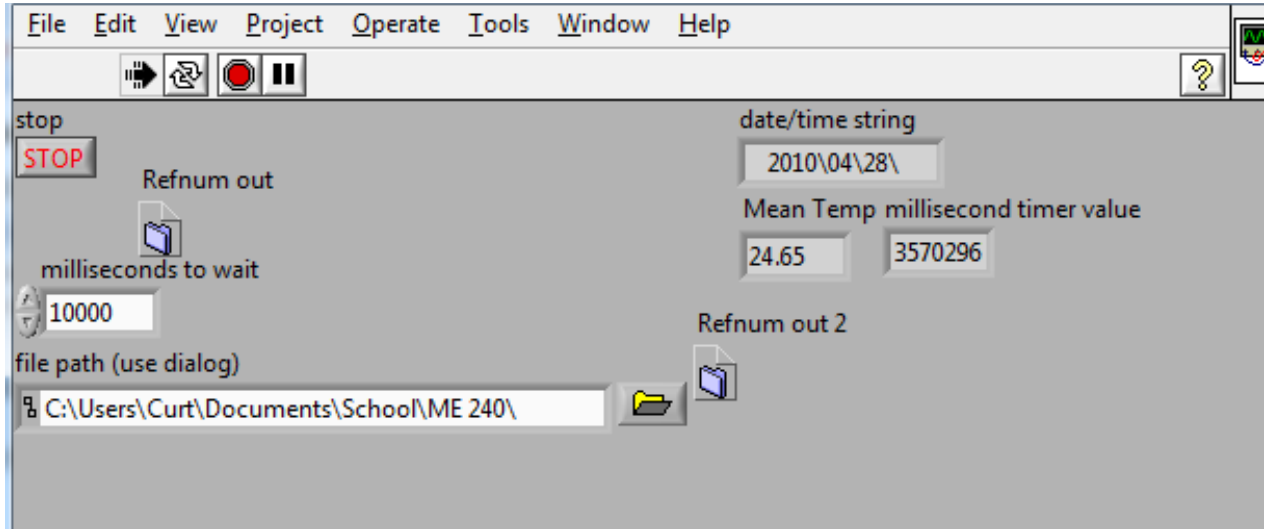
Appendix – Attachments

Figure 8 – Program Screenshot

Appendix – Attachments

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Raw Data of Solo Cup

Part 5_a.vi
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Last modified on 4/28/2010 at 8:54 PM
Printed on 5/3/2010 at 12:48 AM

stop

STOP

Refnum out

milliseconds to wait

10000

file path (use dialog)

C:\Users\Curt\Documents\School\ME 240\

date/time string

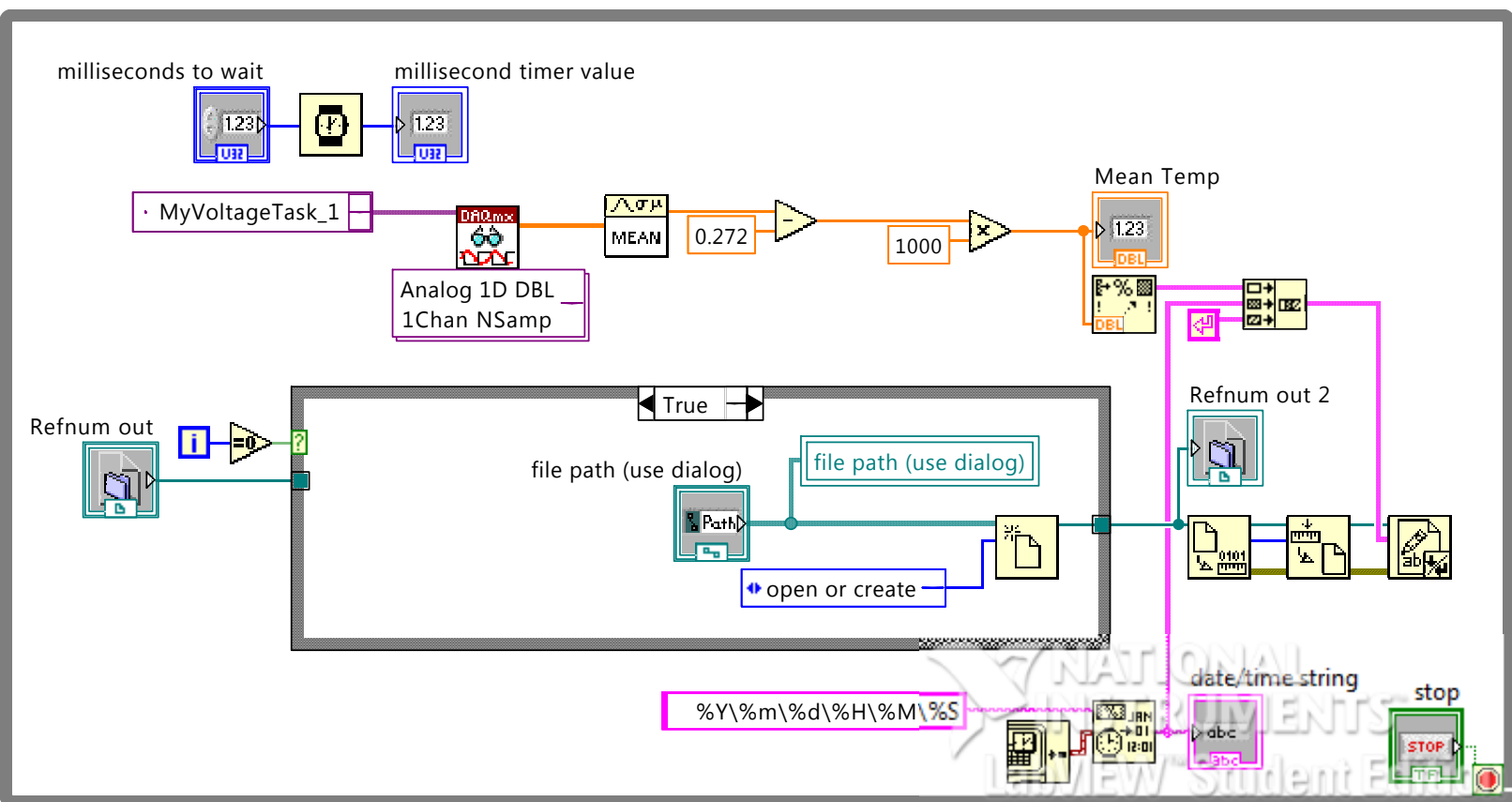2010\04\28\

Mean Temp   millisecond timer value

24.65   3570296

Refnum out 2

milliseconds to wait   millisecond timer value

MyVoltageTask_1

Analog 1D DBL
1Chan NSamp

MEAN   0.272   1000   Mean Temp

Refnum out   i =0

True

file path (use dialog)   file path (use dialog)

Refnum out 2

open or create

%Y\%m\%d\%H\%M\%S   date/time string   stop

False

file path (use dialog)

read/write

DAQmx Read (Analog 1D DBL 1Chan NSamp).vi
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1D DBL 1Chan NSamp).vi

DAQmx Read.vi
C:\Program Files (x86)\National Instruments\LabVIEW 2009\vi.lib\DAQmx\read.llb\DAQmx Read.vi

Part 5_a.vi
C:\Users\Curt\Documents\School\ME 240\AD592\Part 5_a.vi
Last modified on 4/28/2010 at 8:54 PM
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NI_AALBase.lvlib:Mean.vi
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