**Lab Assignment 1. Time Response and Introduction to CR1000 DataLogger. 20 points**

1. **Objective**: Become familiar with steps involved to collect data from a sensor (in this case a copper-constantan thermocouple) using the CR1000 datalogger and the Loggernet software on the netbook. Estimate the time response of the thermocouple.
2. **Before the Lab Session**
   1. You must complete the online Lecture 2 assignment for Lab 1 by noon January 9. Failure to do so means you will not be able to start the lab.
   2. **Read through the entire assignment so that you understand what is being required. Ask questions, if things don’t make sense. You need to complete through STEP 8 in the lab. If you run out of time, then arrange with a TA to continue after class or at another time.**
3. **Lab Partners**
   1. You will work in 2-3 member teams. Everyone needs to participate and work collaboratively
   2. Everyone should be able to show competency in completing the work independently as well
4. **Equipment List. You will check out, be responsible for, and return the following:**
   1. PS100 power supply (may be shared)
   2. CS1000 datalogger
   3. USB- 9 pin serial cable
   4. CR1000KD keypad display and cable
   5. Copper-constantan thermocouple
   6. Straight screwdriver
5. **Setting up the Logger**
   1. Create a folder on the netbook Desktop using your last names: e.g., CROSMAN\_LUCKE
   2. Click on LoggerNet and select “Setup” from the “Main” menu. You should be in the EZ View. If you see a CR1000, click on the CR1000 and select Delete. DON’T DELETE ANYTHNG ELSE!
   3. Add a CR1000 data logger. You should see DataLogger Name “CR1000”.
   4. Select “Direct Connect” Connection Type. Be sure the serial cable is connected from the netbook to the RS-232 port on the logger. Select from the pull down menu the serial port that says Prolific or another name. If you don’t see one, STOP, and ask for some help. Each logger will have a different COM port active. Write down the number, e.g., COM3.
   5. Leave Datalogger settings alone. Test Communications. If you do not get to the DataLogger Clock option, then something is haywire and STOP and ask for help. If everything is working, don’t send program, select Finish.
6. **Creating a Program and Sending it to the Datalogger**
   1. Step 1.
      1. From the main menu, select under Program the “Short Cut” option
      2. You should see the CR1000 icon and select that
   2. Select New Program
      1. From the main menu, select CRBasic Datalogger model (CR1000)
      2. Scan interval (1 sec)
      3. You may or may not see the following:
         1. AC Noise Rejection (60 hz)
         2. Sensor Support (CS Inc.)
   3. Step 2. Sensors
      1. Leave Default measurement of battery voltage (BattV)
      2. Add from sensors- category Temperature: Wiring Panel Temperature. Click red arrow and should show up on right side: Sensor -Panel Temp, Measurement: PTemp\_C
      3. Add 1 Type T (copper-constant thermocouple). Use default settings. Check wiring diagram. Follow instructions and insert thermocouple into wiring panel. Blue (copper)- 1H. Red (constantan) 1L.
   4. Step 3. Output
      1. Store every 1 second for Table 1
      2. Click on sensor on left and select sample for each of the 3 variables. They should show up on the right
      3. Save program to your Team’s Desktop folder as “Lab1”. Do not send the program to the Datalogger yet
   5. Step 4. From Main Menu, select Connect.
      1. Click on the Connect icon
      2. Click on send (Program). Select your program from your Desktop folder
      3. If for any reason, you can’t connect or the program does not compile, STOP and ask for help
7. **Monitoring Using the CR1000KD**
   1. Normally, we will use the netbook to collect data, but the CR1000KD is quite powerful and convenient
   2. Connect the CR1000KD to the CS I/O port
   3. Verify that your program is loaded
   4. Select Home (use Enter key to select everything other than Home; Esc to go back, up/down arrows to move through menus, etc.)
   5. *Question 1.* Select Real Time Tables. Select Public. Record the following:

|  |  |  |
| --- | --- | --- |
| BattV | PTemp\_C | Temp\_C |
|  |  |  |

* 1. *Question 2.* Touch the thermocouple lightly for 10 seconds. Record the following while you are touching the thermocouple:

|  |  |  |
| --- | --- | --- |
| BattV | PTemp\_C | Temp\_C |
|  |  |  |

* 1. Go back to the Data Menu and select Graph Setup. Select Graph Type Roll (with Scaler Auto). Then go back to Real Time Table and to the Public Table. Select Temp\_C and then select Graph
  2. *Question 3*. After 30 seconds or so, estimate the range (0C) of variability of thermocouple temperature (lowest and highest values).

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| --- | --- |
| Observed Range in thermocouple temperature |  |

* 1. *Question 4.* Jot down whether you think you can distinguish between whether this range is due to changes in the environment or electronic noise associated with the thermocouple.
  2. *Question 5*. Continuing from h, hold the thermocouple for about 15 seconds, watch the graph to see how rapidly the temperature increases, now release the thermocouple and watch how rapidly it cooled off. Record the original temperature, the max temperature, and the temperature after the sensor cools off.

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| --- | --- | --- |
| Original temperature | Peak Temperature | Final temperature |
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* 1. *Question 6.* Jot down your thoughts for later. Does the sensor cool off as fast as it warmed up? Why?

1. **Collecting data to estimate the time response of the thermocouple** 
   1. Go to the Final Storage Data and select Table 1
   2. Move the cursor to the right to see Temp\_C. Note the time at the top. Use the end option to go to the last measurement.
   3. Now, touch the thermocouple junction for 10 seconds and then remove your fingers.
   4. Use Pg Up until you see the measurements when you held the thermocouple and then released it.
   5. *Question 7.* Copy down the values from your initial temperature for the next 20 seconds or so and then a temperature after a minute or longer after the temperature has returned to some final value. The critical values are the one right as you stopped touching the thermocouple (Ti), the values each of the next 15 seconds, and the final value (Tf).

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| --- | --- | --- | --- | --- | --- |
| Time(sec) | Temperature (oC) | (T- Tf)/(Ti-Tf)  (complete later) | Time(sec) | Temperature (oC) | (T- Tf)/(Ti-Tf)  (complete later) |
| Initial | Ti= | 1 |  |  |  |
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|  |  |  | Final | Tf= | 0 |

1. **Finishing Up.**
   1. STOP! Have an instructor check your raw data before disconnecting anything.
   2. If everything is ok, repeat 8 for each member of your group.
   3. Then disconnect and turn in all equipment.
2. **Computing the time response of the thermocouple**
   1. Compute the third column, hereafter referred to as the ratio, (T- Tf)/(Ti-Tf) in #8.
   2. Plot using Matlab or other plotting software (or simply semilog paper) the values of the ratio on the y axis vs time (sec) on the x axis. The y axis should be log, so don’t plot the final temperature value (ratio value of 0).
   3. Draw using a straight edge or use the plotting software to estimate the best linear fit to the data (straight semilog line). You should see scatter about this line with points roughly equally above and below the line, not a straight line from the first point to the last point necessarily. This is not a “connect the dots” line, but one straight line that best fits all the data.
   4. (1) Estimate the response time (in sec) of the thermocouple by determining the time that the thermocouple takes to reach 36.8% of its final temperature based on your linear fit (NOT THE RAW DATA). Start from the value 0.368 on the y axis, put a tic mark on your line of best fit horizontally from that point, and then go down to the x axis to find the time. AGAIN, DO NOT USE the value you might have obtained directly from the sensor according to the table in question 8. (2) Repeat starting from the y value of 0.135, and estimate twice the response time (in sec) to reach within 13.5% of its final temperature. (3) Estimate the response time by determining the slope of the line (change in y over change in x), multiplying by -1, and inverting.
3. **Final Steps**
   1. Create a lab report. This must be typed except for the figure. Use the following template.

**Project Report. Laboratory Assignment 1. Due January 16. Must be submitted as a pdf into Canvas. If you don’t know how to do that, ASK IN ADVANCE!**

**Your Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Group Member Names \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Restate the lab objective in your own words. Do not repeat verbatim.**

1. *Question 1.* Select Real Time Tables. Select Public. Record the following:

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| --- | --- | --- |
| BattV | PTemp\_C | Temp\_C |
|  |  |  |

1. *Question 2.* Touch the thermocouple lightly for 10 seconds. Record the following while you are touching the thermocouple:

|  |  |  |
| --- | --- | --- |
| BattV | PTemp\_C | Temp\_C |

1. *Question 3*. After 30 seconds or so, estimate the range (0C) of variability of thermocouple temperature (lowest and highest values).

|  |  |
| --- | --- |
| Observed Range in thermocouple temperature |  |

1. *Question 4.* Can you distinguish between whether this range is due to changes in the environment or electronic noise associated with the thermocouple?
2. *Question 5*. Record the original temperature, the max temperature, and the temperature after the sensor cools off.

|  |  |  |
| --- | --- | --- |
| Original temperature | Peak Temperature | Final temperature |
|  |  |  |

1. *Question 6.* Does the sensor cool off as fast as it warmed up? Why?

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| --- | --- | --- | --- | --- | --- |
| Time(sec) | Temperature (oC) | (T- Tf)/(Ti-Tf)  (complete later) | Time(sec) | Temperature (oC) | (T- Tf)/(Ti-Tf)  (complete later) |
| Initial | Ti= | 1 |  |  |  |
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|  |  |  | Final | Tf= | 0 |

*Question 8.* Include a scanned or electronic copy of your plot.

*Question 9.* (1) Estimate the response time (in sec) of the thermocouple by determining the time that the thermocouple takes to reach within 36.8% of its final temperature based on your linear fit.

(2) Estimate the response time to reach within 13.5% of its final temperature based on your linear fit.

(3) Estimate the response time from the slope of the line.

(4) Do these estimates agree? Why or why not?

*Question 10.* Each team member should have separate results for Question 9. Compare your estimates of the response time to theirs. They shouldn’t be identical, but they shouldn’t be wildly different. Provide an explanation for similarities or differences based on how each of you conducted the data collection.

*Question 11.* *Graduate students only.* It is important to recognize that there are other manufacturers of data loggers. Look at the information available here: <http://www.nexsens.com/pdf/nexsens_isic_spec.pdf> and

<http://www.nrgsystems.com/sitecore/content/Products/~/media/Files/PDFs/SymphoniePLUS_Overview.ashx>

Discuss in a paragraph what are some differences between the CR1000 and the NRG product used extensively in the wind energy field.

*Question 12. GRAD STUDENTS ONLY.* Read (not in depth but get a good feel of what their study was about) the Ruffieux and Joss (2003) paper on the Swiss radiosonde that uses a copper-constantan thermocouple. The article is available here <http://ams.allenpress.com/archive/1520-0426/20/11/pdf/i1520-0426-20-11-1576.pdf> . Focusing on their laboratory experiments, discuss in a paragraph or two their reasoning for using very thin wires and other aspects of the laboratory work.