ECE437: Sensors and Instrumentation

Lab 6: Electrical Characterization of Temperature Sensor

Introduction

In the previous two labs, you developed two sets of frameworks. The first framework enabled you to collect data from the temperature sensor and transmit this data to the PC. The second framework enabled you to control various instruments in the lab from Python. With these two sets of skills, you can design automatic test benches for evaluating the performance of the temperature sensor. You can also extend these skills to other sensors on our custom board and automatically evaluated their performance. In this lab, you will evaluate the noise performance of the temperature sensor at different temperatures using an automatic test bench developed in Python.

WARNING: Since we will be heating up the resistor on a test board, be extremely careful not to touch this resistor. You can burn yourself if you touch the resistor once it is connected to the power supply.

Relevant Documents for this Lab

Required reading material for this lab:

1. The temperature sensor used in our custom board is from Analog Devices and the part number is ADT7420. You will refer to this document to compare the noise performance of the sensor.

Additional reference material:

1. If you were not able to successfully implement the I2C protocol in the previous lab, we have provided Python code together with a bit file that enable receiving data from the temperature sensor. You can use this framework as a starting point for this lab. The code is available on the course website.

The Goals of This Lab Are:

1. Learn how to develop automatic test benches in Python to evaluate the noise performance of the temperature sensor.

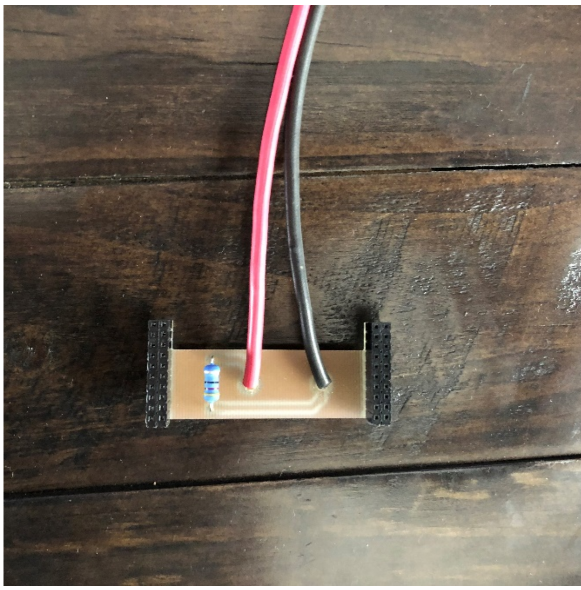
Prelab Questions (20 pts):

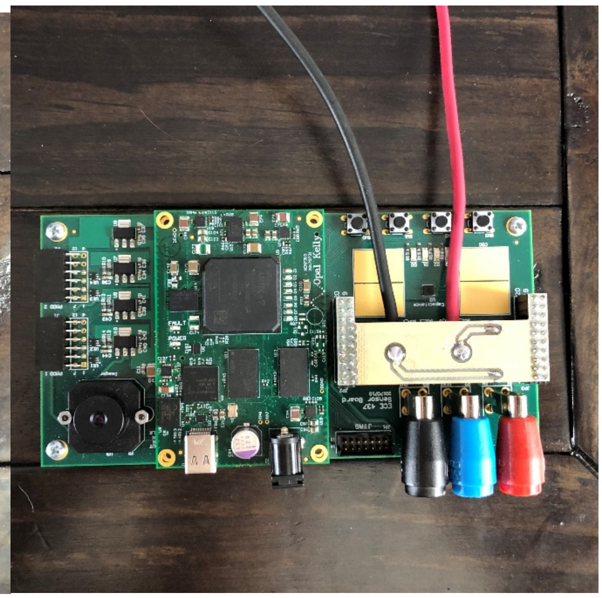
1. Look at the color coding of the power resistor used for generating heat and determine its value and tolerance. An image of the power resistor is provided below. (10 pts)
2. The maximum power rating for the resistor is 0.5W. Based on the resistor value that you determined in question 1, what is the maximum voltage you can apply without damaging the resistor? (10 pts)

Power Resistor Test Board

We have developed a test board that contains a power resistor, whose two terminals are connected to RCA cables. The RCA cables will be connected to the power supply and will supply power to the resistor. As different voltages are applied across the resistor, different thermal emissions will be achieved due to the power consumption.

An image of the test board is provided bellow. The board also mates with the sensor board as indicated in the next image. Do not connect these two boards yet.





Checkpoint 1 (40 points)

- Make sure that the power resistor board is not connected to the sensor board. Connect the resistor board only to the power supply. You will write Python program that will enable you to apply at least 50 different voltages to the resistor and generate different temperatures. Calculate the maximum voltage you plan to apply to the resistor and show your calculations to the TA before proceeding. You do not want to exceed the power rating of the resistor as you will destroy it. Do not run your code until you show your approach to the TA. (10 pts).

- Sweep the voltage access the resistor from 0V to the maximum value you determined previously. Make sure you have at least 50 different voltages applied accross the resistor. Connect a multimeter in series so that you can measure the current flowing through the resistor. Your code should read the current and voltage consumed by the resistor and if the power consumption of the resistor exceeds 0.5W, then your code will turn off the power supply automatically. This way we mitigate the risk of damaging the resistor.

- For each voltage value applied across the resistor, take 100 readings of the supplied current and voltage to the resistor. Compute the mean and standard deviations for these 100 measurements at a particular temperature. Plot the mean and standard deviation for the power consumption, voltage and current for the 50 different voltages applied across the resistor. (10 pts)

- Why do you see variations in these measurements and what is the theoretical formula that models this behavior? How well do these measurements (i.e. variations in the current and voltage) follow the theoretical model? (20 pts)

Checkpoint 2 (60 points)

- Develop Python code that will enable you to sweep the voltage across the resistor as you did in Checkpoint 1 and for each applied voltage collect 100 readings from the temperature sensor.
    - Compute the mean and standard deviations for the temperature readings for each voltage applied on the power resistor. Plot the mean and standard deviation of the temperature for the different voltages applied on the power resistor (40 pts)
    - Is the standard deviation different for different temperatures (i.e. voltages applied on the power resistor)? Why do you think this is the case? Look over the datasheet and locate a figure with a similar measurement. Include this figure in your report and comment on the differences and similarities between the two results. (20 pts)

This code reads data from the temperature sensor and outputs the results on the screen. The bit file programs OpalKelly's XEM7310 board with a finite state machine that implements I2C protocol. With this protocol, temperature data is received from the temperature sensor to the FPGA. Then the FPGA transfers the data from the two registers containing the temperature data to the PC using OKWireOut.