ECEG 201 Laboratory 4, Calibrating the Feather ADC

Introduction

Your task for this exercise is to estimate the uncertainty in the analog-to-digital converter (ADC) on the Feather M0 Express board. You will only consider two sources of uncertainty: offset error and gain error. You must use your Analog Discovery to make all of the measurements and supply any test voltages. Using these measurements, you will derive a formula for the actual ADC input voltage as a function of the ADC's integer digital output value.

Deliverables

You must turn in your report for this activity by the beginning of class on Wednesday, 2020-02-26. Each student will work individually on this activity. You may discuss the activity with other students but you must do your own work and the report you submit must be entirely your own work.

Your report should be created entirely by computer. Use the general guidance provided in Test and Laboratory Reports, particularly the last section on "Academic Laboratory Reports". Note that the example given there talks about three different tests but your report will discuss a single "test".

Your name, the course name, and the date must be printed at the top of the first page. **Do not** add a title page. Your report should include (but not be limited to) the following content:

- The number written on the Feather's micro-USB connector
- Diagrams of test circuit(s) you used
- Descriptions of all of the **quantities** you measured and the instruments used to make those measurements
- A presentation of the test data. The value of every measurement you make should be provided in some way.
- Presentation and explanation of any equations you used to calculate values that were not directly measured

In addition to the written report, you must send the instructor a copy of the Python code that you used on the Feather. Attach the Python source file to an email message; do not import it to a word processor file or modify it in any way. The file you send must be suitable for execution on a Feather with no changes. You should follow the formatting and style guidelines give in PEP 8 *Style Guide for Python Code*. The deadline for submitting your code is the same as that for the written report.

Procedure

We have discussed the behavior of ideal ADCs and the recommended software for converting an ADC value to the corresponding input voltage. However, we know that the ADC on the Feather is not ideal. The offset and gain errors in the ADC will lead to uncertainty in measured voltage values, and if those measured voltages are from a temperature sensor then we have uncertainty in the temperature values. If we can quantify the offset and gain errors, and if they are repeatable, then we can try to correct any measured voltages and reduce their uncertainty.

We know that the voltages from the MCP970X temperature sensor will be between 0.4 V and 1.5 V at any reasonable room temperature. We will assume that the ADC is linear between those two voltages. So, making measurements of the ADC digital output at these two input voltages will allow us calculate the error for each measurement and to determine the coefficients of a linear function for the response of the ADC.

As usual, this is easier said than done. You may find that the digital output from the ADC is very noisy, and consecutive measurements are not repeatable. In that case you can average some number of samples to eliminate any random noise in the data. When you calculate the average you should also keep track of the minimum and maximum measured values... if the difference between the minimum and maximum values is significant compared to the average then we may have bigger problems (to be addressed later). If you decide to average the ADC output values be sure to describe your method and document all three of the values (minimum, average, and maximum).

It can also be tricky to get precise output voltages from the Analog Discovery. Be sure to use the voltmeter function to measure all voltages; don't rely on the power supply settings. Document the actual voltages used.

Be mindful of significant digits when rounding calculated values.

As a sanity check, use the transfer function you found for your sensor in previous lab exercises and calculate the voltage the sensor would produce at 25 °C. Demonstrate how well your linear function for the ADC works when this voltage is applied.