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MW 3:30-5 Section

Lab 9 Report

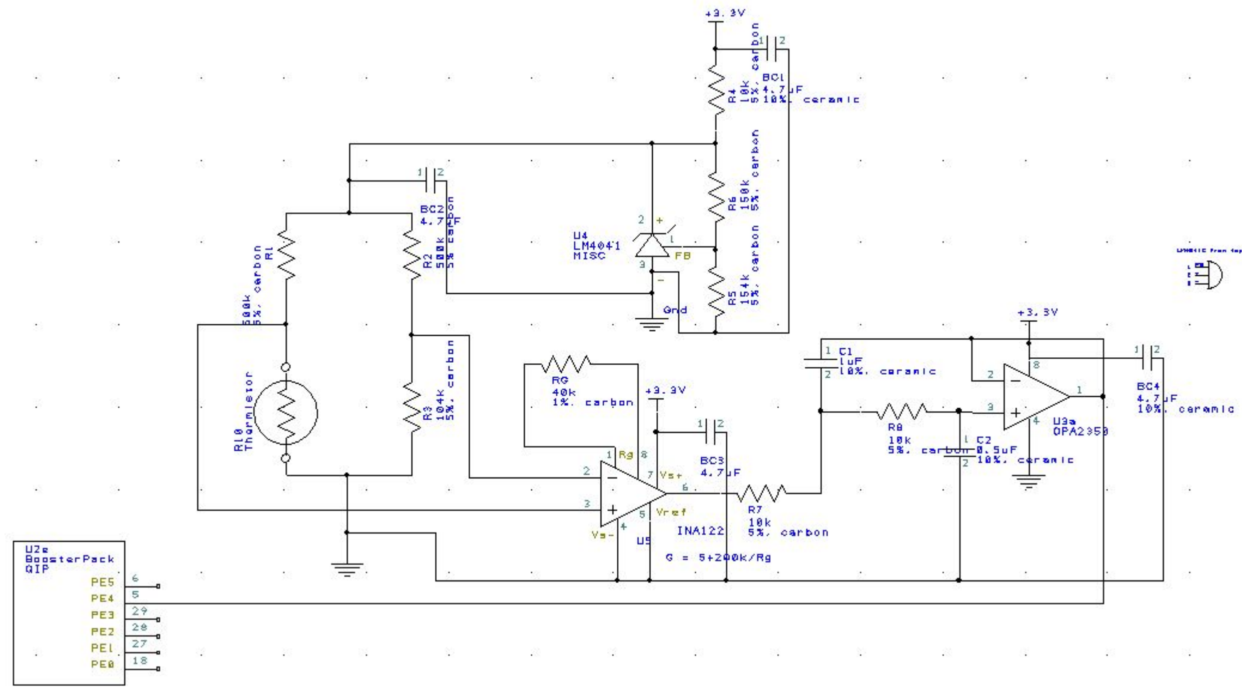
Deliverables (exact components of the lab report)

A) Objectives (1/2 page maximum)

The goals of this lab were to understand the Nyquist Theorem from observing the sampling of the ADC and learn how to use the nonlinear thermistor to create a digital thermometer.

B) Hardware Design

Circuit diagram of the thermistor interface



C) Software Design (a hardcopy software printout is due at the time of demonstration)

1) Calibration data (procedure 5 and the calib.h file)

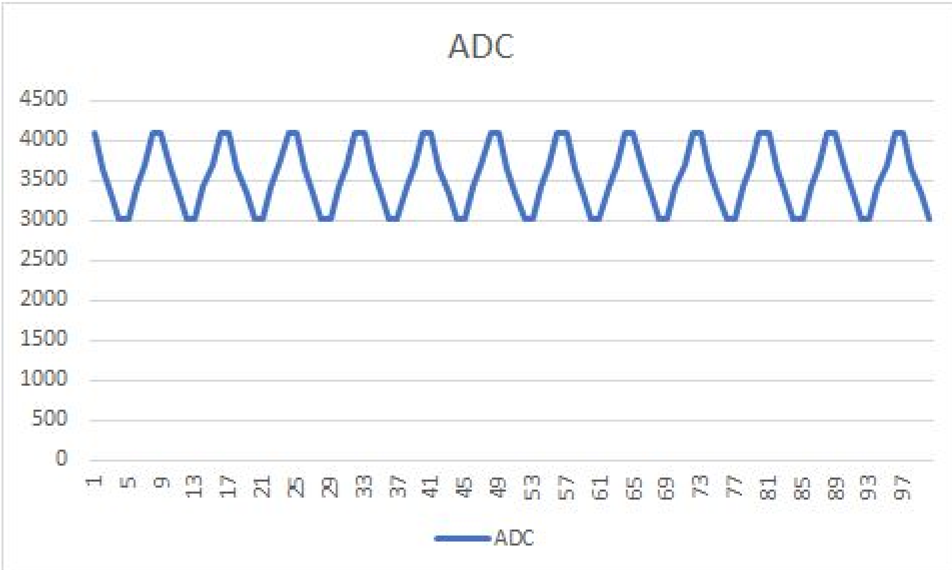
2) Low level ADC interface (ADC.c and ADC.h files)

3) Main program used to measure temperature

S/W files on Github

D) Measurement Data

1) Sketch three waveforms (procedure 1)



The function generator would not produce an accurate 0-2.65V as we needed (Would only produce ~1.7-2.2V?) so we could not get accurate results.

2) Static circuit performance (procedure 2)

500kΩ/0C: 4037 => 2.65V
200kΩ/10C: 3232 => 2.12V
100kΩ/25C: 1246 => 0.82V
71kΩ/32C: 574 => 0.38V
50kΩ/40C: 9 => 0.01V

3) Dynamic circuit performance (procedure 3)

The function generator would not produce an accurate 0-2.65V as we needed (Would only produce ~1.7-2.2V?) so we could not get accurate results.

4) Accuracy (procedure 6)

Xti	Xmi	% error	
24.23	26.25	8.336773	In Lab full of people
21.20	23.09	8.915094	In lab hallway
29.82	33.02	10.73105	Outside
24.89	26.42	6.147047	In Lab full of people
24.78	26.45	6.739306	In Lab full of people

Average % error: 8.173854564

5) Reproducibility (procedure 7)

Temp	Std Dev
23.96	0.157127
24.01	
24.15	
24.18	
24.23	
24.30	
24.35	
24.38	
24.42	
24.43	

E) Analysis and Discussion (give short answers to these questions)

1) What is the Nyquist theorem and how does it apply to this lab?

The Nyquist theorem states that you must sample a signal with frequency *f* at frequency 2*f. Since this lab is measuring a signal running at 10 Hz, we must set our ADC to record values at at least 20 Hz. However, the Valvano postulate says that for anti-aliasing purposes you should sample a signal at 10*f, so we actually sampled at 100 Hz.

2) Explain the difference between resolution and accuracy?

For this lab, resolution meant how small of a difference between temperatures we could measure (10.01 C vs 10.0095 C). Accuracy was how close to the real value we could get. An issue we had was the self-heating of the thermistor skewing results (especially outside). As time went on, the thermistor would measure ~2C above the actual temperature.

3) Derive an equation to relate reproducibility and precision of the thermometer.

Precision ≈ 1/(standard deviation)

4) What is the purpose of the LPF?

The low-pass filter was to filter out high-frequency noise from the amplifier. We used a Butterworth Filter as it gave sharp drops in gain at our cutoff frequencies.

5) If the R versus T curve of the thermistor is so nonlinear, why does the voltage versus temperature curve look so linear?

Since we are only measuring from 0-40C, we can linearize that small region without losing much accuracy. This works especially well away from extreme values, e.g. -40C or 100C.

6) There are four methods (a,b,c,d) listed in the 4) Software Conversion section of methods and constraints. For one of the methods you did not implement, give reasons why your method is better, and give reasons why this alternative method would have been better.

One of the methods that was not used was implementing a large lookup table of all ADC values and corresponding temperature values. It would have been cumbersome to calculate all the values and write down all the values in an array or struct. However, using a lookup table would have been faster for the processor over our chosen method of making calculations with our derived equation.