EE 445L - Lab 9: Temperature Data Acquisition System

Joshua Bryant jmb6357

James Morris jsm3288

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1 Objective

The goals of this lab are to study ADC conversion, the Nyquist Theorem, the Valvano Postulate, and their implications in real world analog systems. These concepts will be studies by developing a temperature measurement system using a thermistor.

2 Hardware Design

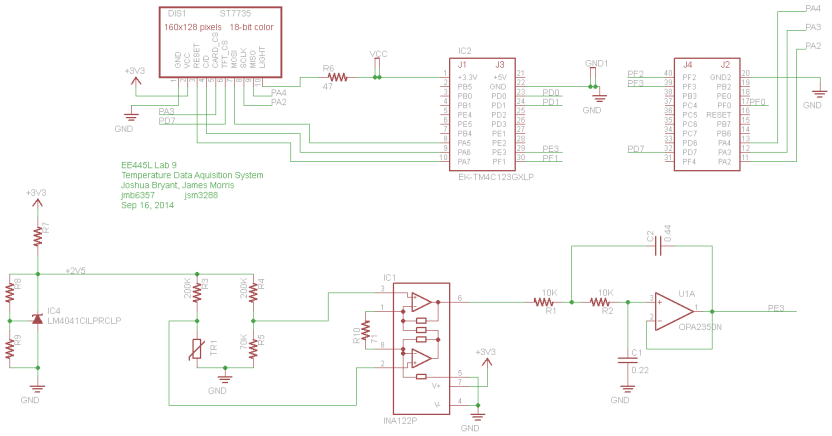

Figure 1: Circuit diagram of the thermistor interface.

3 Measurement Data

1) **Static Circuit Performance Measurements:**

Resistance (Ω)	Themistor Circuit Output (V)	LPF Output (V)	ADC Value
Open (∞)	3.32	0.334	4025
110K	2.84	0.282	3375
100K	2.52	0.254	3046
92K	2.36	0.234	2790
82K	2.04	0.202	2420
72K	1.72	0.166	1965
62k	1.32	0.130	1525
Short (0Ω)	0.12	0.01	5

2) **Dynamic Circuit Performance:**

Frequency (Hz)	Input (V)	Output (V)	Gain (Vout/Vin)
1	0.008	0.160	20
2	0.008	0.160	20
3	0.008	0.240	30
4	0.008	0.140	17.5
5	0.008	0.120	15
6	0.008	0.170	21.25
7	0.008	0.200	25
8	0.008	0.216	27
9	0.008	0.232	29
10	0.008	0.240	30
15	0.008	0.248	31
20	0.008	0.240	30
25	0.008	0.224	28
30	0.008	0.216	27
35	0.008	0.224	28
40	0.008	0.224	28

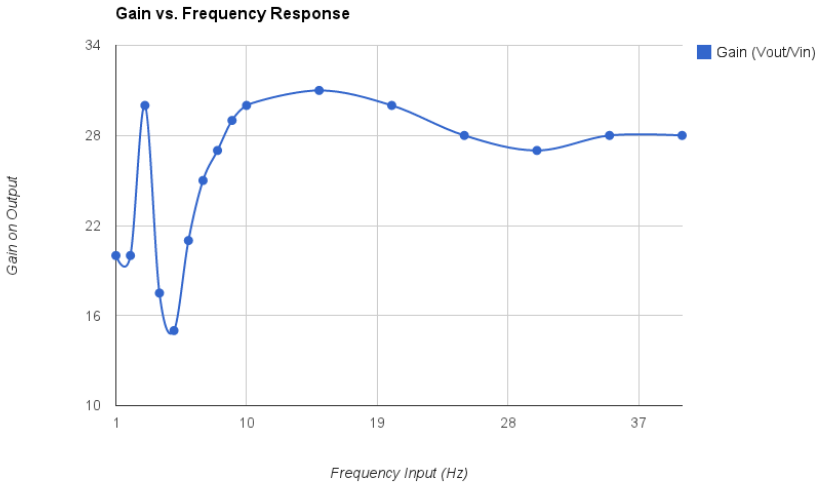

Figure 2: Gain Frequency response of our thermistor interface circuit and the low pass filter from the data above.

3) **Accuracy:**

Fluke Value (°C)	Thermistor Circuit Value (°C)
33	33.62
33	33.20
33	33.35
33	33.54
33	33.23

The average accuracy for the thermistor circuit is 0.388°C.

4) **Reproducibility**

The standard deviation for our system was 0.096°C.

Measurement Number	Thermistor Circuit Value (°C)
1	29.27
2	29.41
3	29.43
4	29.36
5	29.40
6	29.44
7	29.45
8	29.42
9	29.53
10	29.63

4 Analysis and Discussion

a. The Nyquist Theorem is the theorem that states an signal must be sampled at a frequency at least twice it's largest frequency component in order to be sampled correctly. It applies to this lab because we must know the maximum frequency we wish to sample in order to design the low pass filter to cut out most signals above twice this frequency so we get better results from our ADC and reduce the error in the system.

b. Resolution is the smallest difference between values which your system is able to measure. Accuracy is how closely the output value of the system matches what it is actually measuring.

c. The low pass filter is supposed to remove all frequencies above twice the frequency at which we are sampling to reduce aliasing. The reason this works is the low pass filter is being implemented in hardware meaning the signal is not being digitized before sampling. This reduces the aliasing encountered and reduces the computational load on the micro controller considerably.

d. The values of the components chosen for the thermistor circuit and the gain of the instrumentation amplifier helped to "spread out" the exponential decay and make it to where it can be approximated as multiple short linear segments along the curve.

e. One method we did not choose was to implement a large table lookup. The reason was due to memory constraints on the side of our compiler since it would not support flashing that much memory on the board. We implemented a small table lookup with linear interpolation in between data points to reduce the amount of memory that was needed. However, our method requires more computational time than looking up the ADC value and results in slightly more error in the output value due to a linear interpolation of a non-linear signal.