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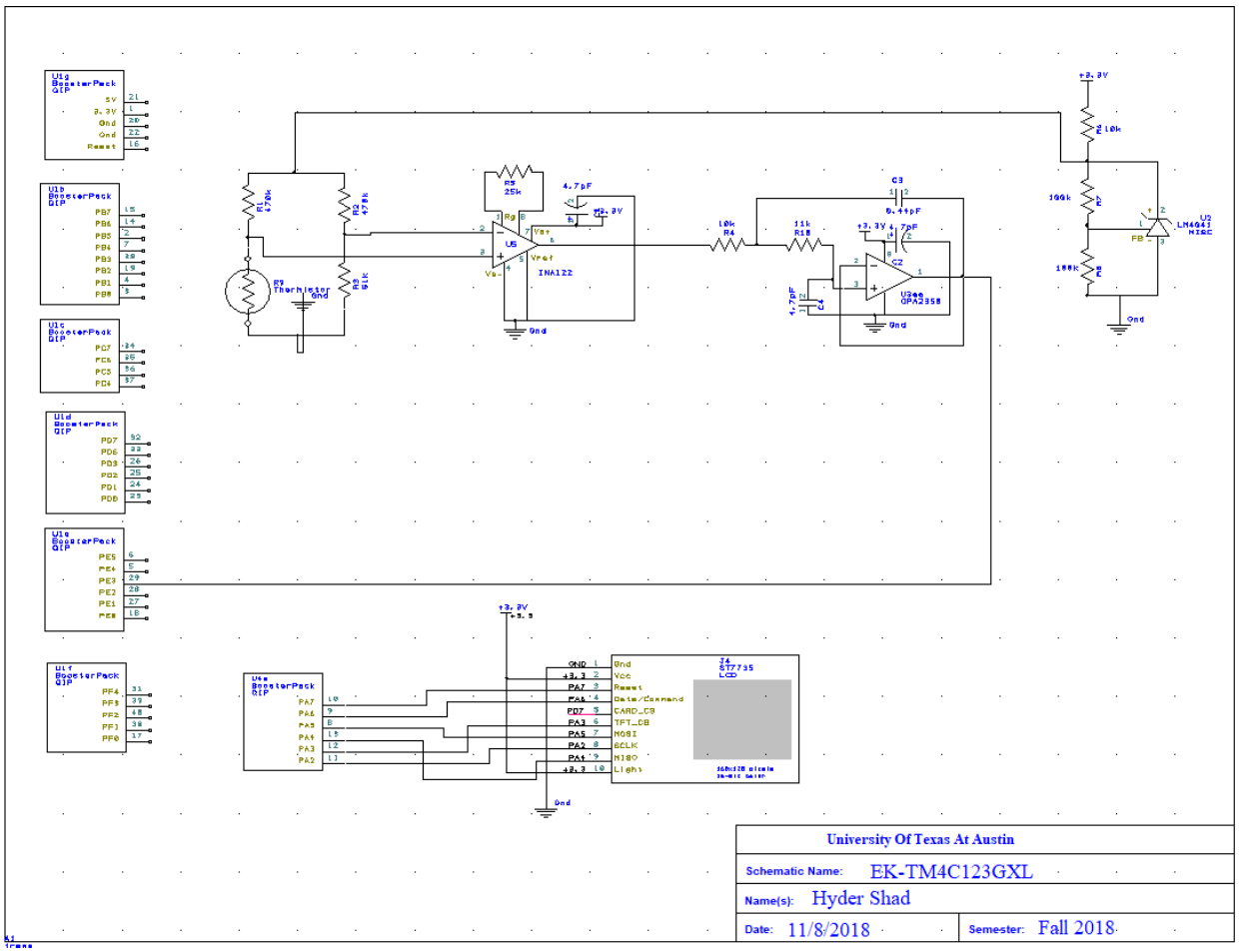
Lab 9 Report

Objectives

Lab 9 will use an ADC on the LaunchPad to provide a digital readout of the ambient temperature. The temperature range is 10 to 40°C. The measured temperature data will be displayed numerically as a fixed-point number on the LCD to two decimal places and the temperature over time will be graphed. The system must have a temperature measurement resolution of 0.1°C or better, with an average temperature accuracy should be 1°C or better. The frequency components of the signal are readings from 0 to 10 Hz.

Hardware Design

Below is a circuit schematic of the thermistor interface with the LaunchPad:



Calibration

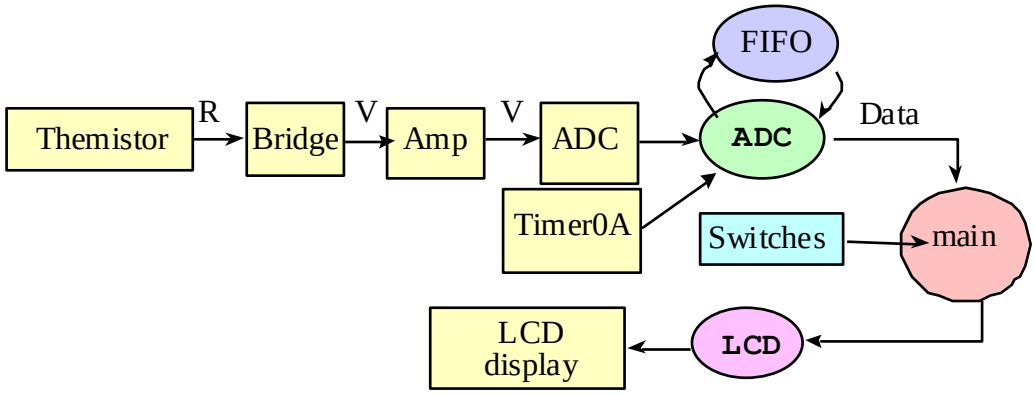
The following values were obtained using the Therm12 xls spreadsheet to calibrate the ADC temperature conversion and circuit parameters:

First point: 101.kΩ at 15.09°C
Second point: 82.32kΩ at 36.04°C
R1 = R2 = 470kΩ
R3 = 65kΩ
V1 = 2.5V
V3 = 0.364V
β = 914.96885
Desired INA122 Rg = 13.98 kΩ
Gain = 19.664
Range: 1161 to 4091 on the ADC
Resolution: 0.007°C <= ΔT <= 0.008°C

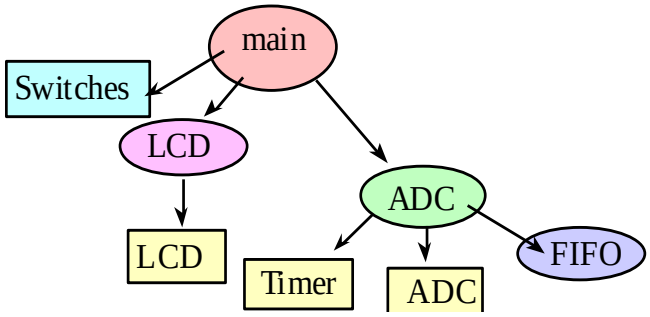
The ADCdata, Tdata, and Rdata tables produced by the spreadsheet are included in the "calibration.h" file submitted along with this report.

Software Design

Please see the associated C and H files submitted along with this report for the Lab 9 software modules. The software design was based off the following data flow and call graph charts:



Data-flow graph



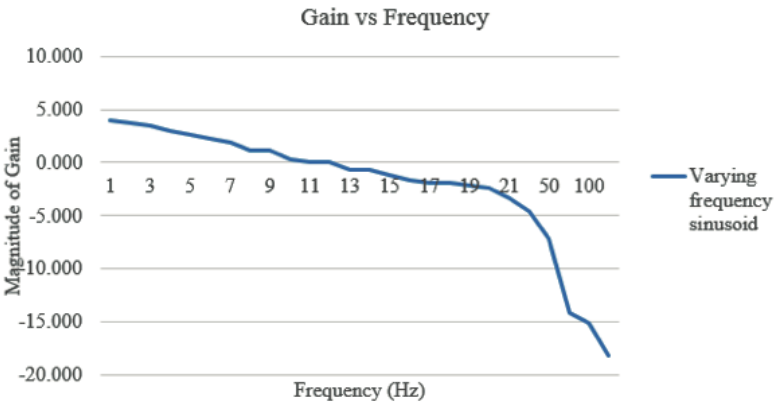
Call graph

Measurement Data

2. Static analog circuit test:

R (kΩ)		Vs (V)	V2 (V)	V2 - V3 (V)
110	Min	2.719	0.987	0.623
110	Max	3.067	1.738	1.374
100	Min	2.016	1.102	0.738
100	Max	2.01	1.124	0.76
90	Min	1.215	0.945	0.581
90	Max	1.228	1.053	0.689
80	Min	0.269	0.902	0.538
80	Max	0.402	0.991	0.627
open	Min	3.18	2.16	1.796
open	Max	3.25	2.23	1.866
short	Min	-0.09	-0.08	-0.444
short	Max	0.09	0.08	-0.284

3. Dynamic Analog Test:



6. Accuracy:

True Temperature (°C)	Measured Temperature (°C)	Difference
31.5	33.5	2
31.5	33.9	2.4
31.5	33.6	2.1
31.5	33.6	2.1
31.5	33.4	1.9
31.5	33.3	1.8
31.5	33.2	1.7
31.5	33.7	2.2
31.5	33.7	2.2
31.5	34.0	2.5

The average difference across the measurements is 2.09 C

7. Reproducibility

T	T^2
28.68	822.5424
28.51	812.8201
28.46	809.9716
28.93	836.9449
28.45	809.4025
28.16	792.9856
28.19	794.6761
28.44	808.8336
28.65	820.8225
28.48	811.1104
28.46	816.2449
Expectation – 28.57	
Var(T)	0.00159
Std Dev	0.0289256

Analysis

1. The Nyquist theorem is the minimum sampling frequency required to capture the original waveform through retain the waveform's unique shape and characteristics. The theorem states that the sampling frequency must be at least twice that of the input frequency. The Nyquist theorem was applied in Lab 9 to ensure the ADC sampling rate was at least twice the input frequency of 10Hz to gather accurate data. This meant the ADC must sample at least 20 times a second.
2. Resolution is the smallest step of change in value in a system. Accuracy refers to the correctness of information captured. In this system, the resolution is smallest voltage change that the ADC on microcontroller can detect based on the number of bits and the

input range of the particular ADC (0-3.3V with 12 bits). Accuracy is the variance between temperature information recorded by the ADC and the actual environmental temperature information measured by most other analog devices.

3. The precision and accuracy of the thermometer can be determined by finding out the standard deviation and variance amongst measurements when compared to the actual temperature readings.
4. The low pass filter is used to remove high frequency noise that may be present in the input from the circuit to the ADC. Potential sources of noise are the power line interference (at 60Hz), static, and fluctuations in the operating temperature or state of the ICs used.
5. The voltage versus temperature curve looks linear due to the circuit feedback and the mathematical equations used to relate the ADC samples to the actual temperature readings. The lookup tables provide for the corrections necessary to interpret the non-linear behavior as a linear relationship with temperature.
6. The linear method was avoided because the thermistor has a non-linear relationship between its resistance and temperature, and using a linear model would have caused error in the temperature calculations from the recorded ADC values. A large lookup table is better because there is less latency to find a recorded value from the table than there is to take an ADC sample and convert it. The lookup table in this case would not be large compared to the available memory and the fact that memory was not a constraint in this lab means it is feasible.