1. **OBJECTIVES**

The objectives for lab 9 were to study ADC conversion, the Nyquist Theorem, aliasing, analog amplifiers, low pass filters, data acquisition systems, and to develop a temperature measurement system using a thermistor.

1. **HARDWARE DESIGN**

See the schematic (.sch) file included with document.

1. **SOFTWARE DESIGN**

See the software files (calib.h, ADC.c, ADC.h, and main.c) included with document.

1. **MEASUREMENT DATA**
   1. **Sketch three waveforms**

The Nyquist Theorem avoids the problem of Aliasing by ensuring that at least two samples will always fall within one period. Valvano's Postulate takes this further by ensuring at least 10 samples will fall within one period.

* 1. **Static Circuit Performance**
  2. **Dynamic Circuit Performance**

**At MC input:**

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency (Hz) | Ampl.Vout | Ampl.Vin | Gain |
| 1 | 3.28 | 0.34 | 9.647059 |
| 10 | 1.48 | 0.34 | 4.352941 |
| 20 | 0.8 | 0.34 | 2.352941 |
| 30 | 0.6 | 0.34 | 1.764706 |
| 40 | 0.52 | 0.34 | 1.529412 |
| 50 | 0.44 | 0.34 | 1.294118 |
| 100 | 0.44 | 0.34 | 1.294118 |
| 1k | 0.36 | 0.34 | 1.058824 |
| 5k | 0.36 | 0.34 | 1.058824 |
| 10k | 0.4 | 0.34 | 1.176471 |
|  |  |  |  |
|  |  |  |  |

Gain

Frequency

**At Amp Output:**

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency (Hz) | Ampl.Vout | Ampl.Vin | Gain |
| 1 | 3.24 | 0.34 | 9.529412 |
| 10 | 3.24 | 0.34 | 9.529412 |
| 100 | 3.24 | 0.34 | 9.529412 |
| 1k | 3.24 | 0.34 | 9.529412 |
| 10k | 3.16 | 0.34 | 9.294118 |
| 20k | 2.04 | 0.34 | 6 |
| 30k | 1.32 | 0.34 | 3.882353 |
| 40k | 1 | 0.34 | 2.941176 |
| 50k | 0.8 | 0.34 | 2.352941 |
| 60k | 0.68 | 0.34 | 2 |
| 70k | 0.56 | 0.34 | 1.647059 |
| 80k | 0.52 | 0.34 | 1.529412 |
| 90k | 0.44 | 0.34 | 1.294118 |
| 100k | 0.4 | 0.34 | 1.176471 |

Gain

Frequency

* 1. **Accuracy**

|  |  |  |  |
| --- | --- | --- | --- |
| Room Temp By Fluke (degC) | By Thermistor | difference | Average Accuracy (degC) |
| 23 | 22.55 | 0.45 | 0.61 |
|  | 22.38 | 0.62 |  |
|  | 22.49 | 0.51 |  |
|  | 22.28 | 0.72 |  |
|  | 22.25 | 0.75 |  |

* 1. **Reproducibility**

|  |  |  |  |
| --- | --- | --- | --- |
| Independent mesurements | mean | (x-u)^2 | S |
| 21.44 | 21.445 | 2.5E-05 | 0.032015621 |
| 21.46 |  | 0.000225 |  |
| 21.41 |  | 0.001225 |  |
| 21.43 |  | 0.000225 |  |
| 21.4 |  | 0.002025 |  |
| 21.44 |  | 2.5E-05 |  |
| 21.43 |  | 0.000225 |  |
| 21.45 |  | 2.5E-05 |  |
| 21.47 |  | 0.000625 |  |
| 21.52 |  | 0.005625 |  |

1. **ANALYSIS AND DISCUSSION**
   1. **What is the Nyquist theorem and how does it apply to this lab?**

The Nyquist theorem states that in order to correctly represent an analog frequency in digital format, the signal must be sampled at minimum twice the frequency of the signal. The frequency of the temperature signal for this lab was between 0 and 10 Hz so we needed to sample it at least 20 times a second.

**5.2 Explain the difference between resolution and accuracy?**

Resolution is the smallest change in temperature that the system can detect, while accuracy is the measure of difference between the actual temperature and temperature measured by the system.

**5.3 Derive an equation to relate reproducibility and precision of the thermometer.**

**5.4 What is the purpose of the LPF?**

To filter out high-frequency noise to the system.

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

**5.6 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.**

We used hardware timer triggered adc capture. Another method we could have used is software triggered adc capture. Hardware timer capture is more precisely triggered at the correct frequency while software capture can give us more control over where in our program we read data from the adc.