

PCB Report – LAB 16

Single vs Differential Ended signaling and ground noise.

Objective:

In this lab, we compare the quality of the analog signal measurement from a temperature sensor using single-ended and differential pair methods and compare the results.

Component Listing:

- Temperature sensor: TMP36GZ
- ADC: ADS1115
- Arduino uno

Napkin Sketch:

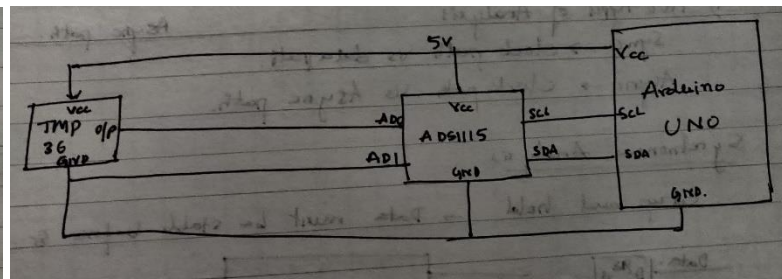
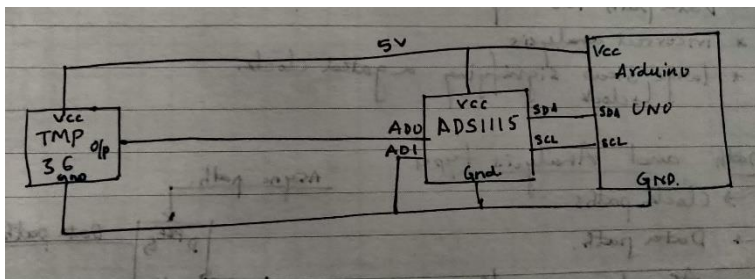


Figure on the left shows the setup for single-ended signaling, and on the right shows the setup for differential-ended signaling.

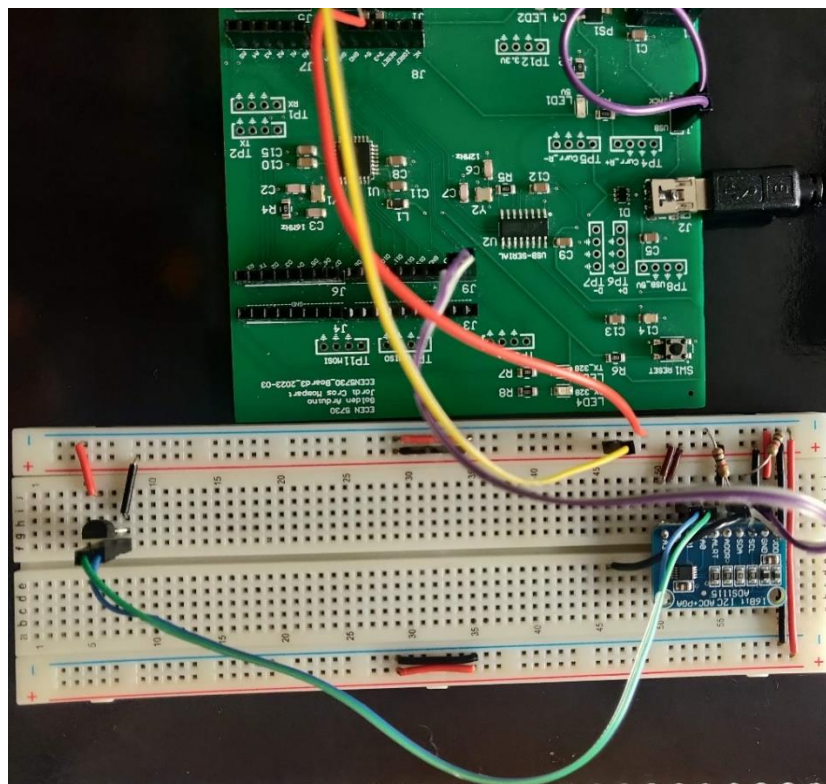
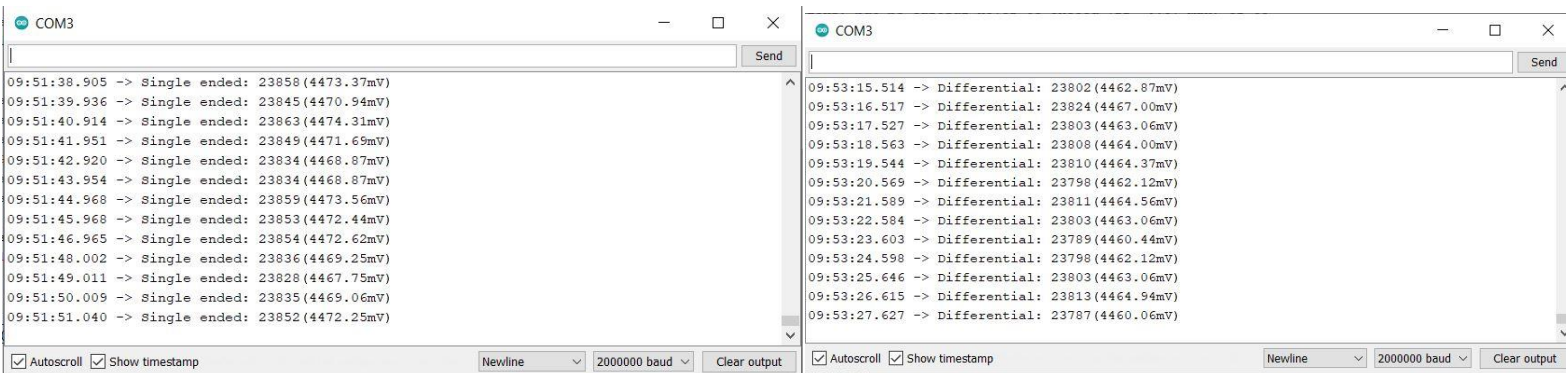


Figure 1.1 Circuit setup for Differential and Single ended signalling.

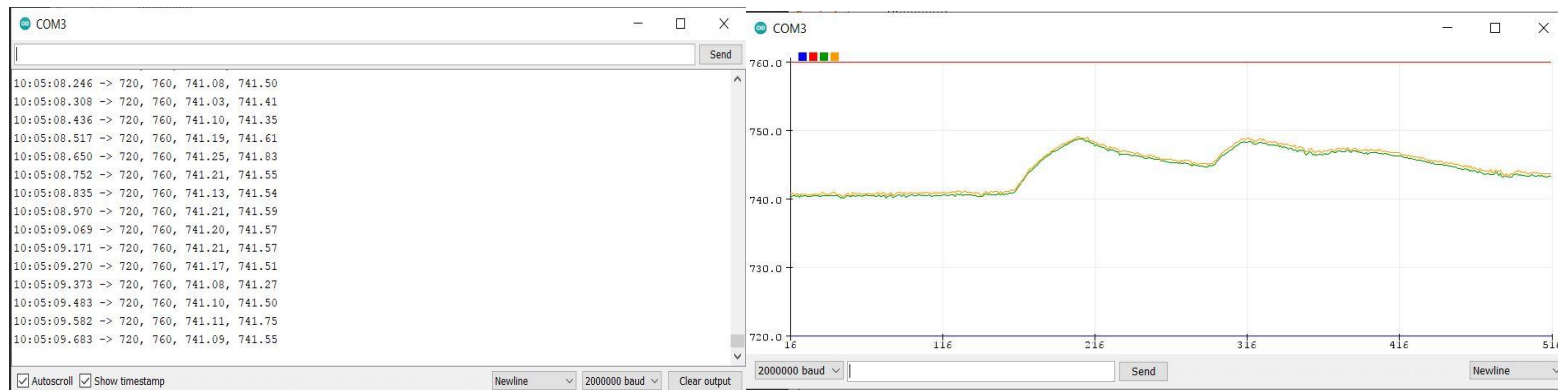
Calculation:

Here, a 16-bit ADC is used to quantize the analog signal varying between 0V and 5V into a digital signal. By using the PGA inside the ADS1115 and setting the gain factor to 4, we represent 65536 voltage levels from 0V to 2.048V, with each bit variation represented by 0.03125mV.

Serial Monitor Output:



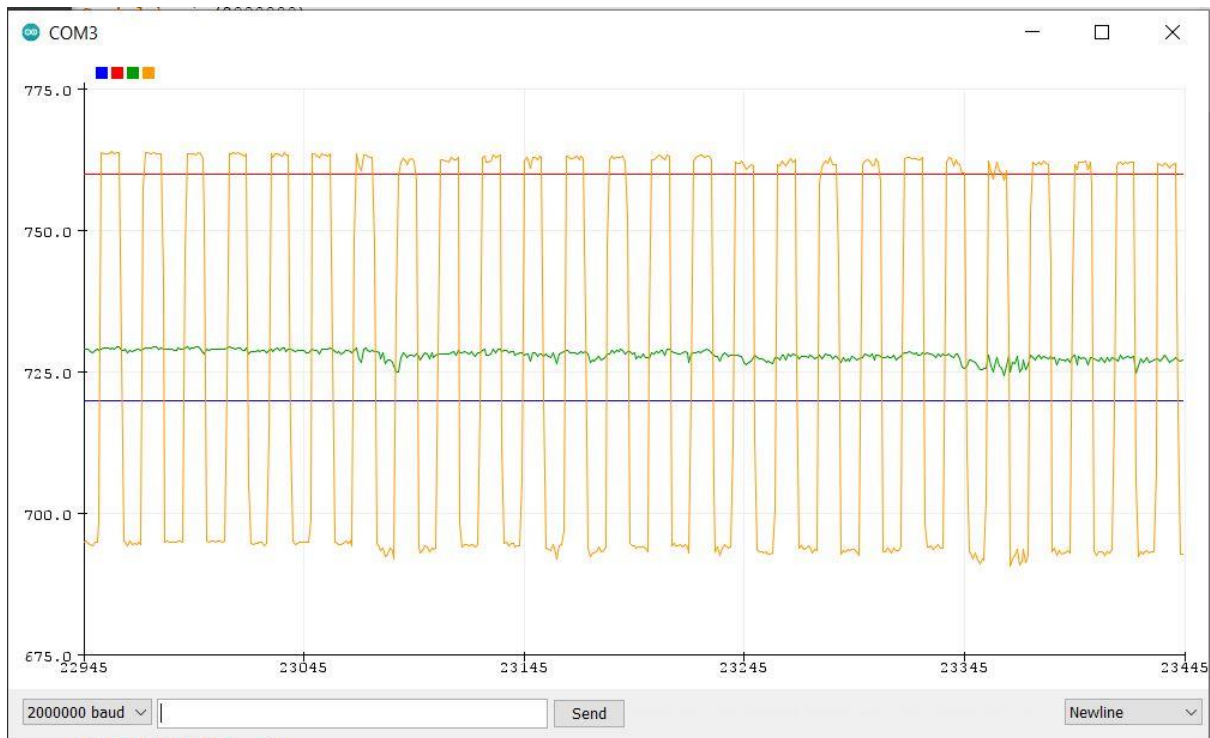
The above images merely demonstrate that there is no difference in voltage readings when testing for single-ended and differential-ended configurations. The values remain the same when the ADC reference input 1 is connected to the temperature sensor output and the other input 2 is connected to the local ground of the ADC.



The first and second columns represent the lower and upper limits of the expected temperature reading values. The third and fourth columns represent the output with respect to single-ended and differential pair measurements.

The plot shows that there is not much difference between the readings from single-ended and differential pair measurements. However, this might not be the correct method for measuring the differential pair. Both reference inputs to the ADS1115 should be directly connected from the temperature sensor, and the ground for input 2 should be connected to the local ground of the temperature sensor, not to the local ground of the ADS1115. After correcting the circuit took the readings once again, but still not seen any noise.

The noise is not noticeable when a few milliamperes of current flow through the 0.04-ohm resistance return path between the ground pins connected to the temperature sensor and the ADS1115 module. Therefore, we applied a periodic square signal with a peak-to-peak amplitude of 20V at a frequency of 1Hz to observe the effect of noise when more current flows through the return path.



Noticed that the readings from the single-ended measurement deviated from the original output by $\pm 35\text{mV}$, whereas the differential pair provided us with the expected value without any effect of noise.

Key learnings:

1. The concept of local ground and noise ground arises due to voltage drops across various locations of the return path/plane caused by large currents. This current passing through an impedance results in voltage drop.
2. The benefit of the differential pair method of reading over single-ended arises when considering the ground voltage as a reference, especially in scenarios where there may be more ground noise present as mentioned in the above point.
3. Limitations of differential pair usage:
 - Traces (signal and ground/p and n) should be of equal length.
 - Traces should be positioned side by side to avoid noise addition to only one of the traces.
 - If possible, traces should be positioned away from other signals to reduce crosstalk.