Lab 16–Differential and Single-Ended Measurements

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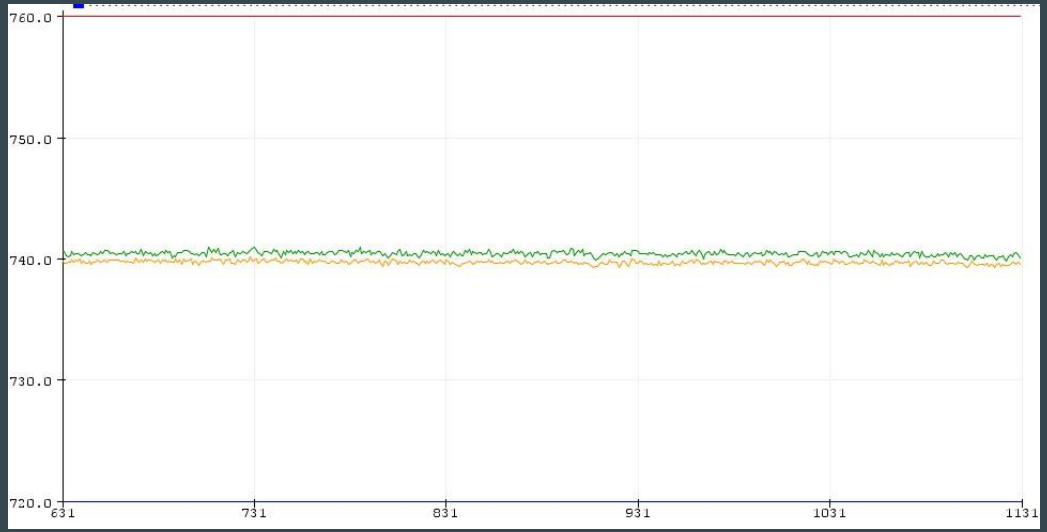
In this lab, we compare the analog signal measurements coming from a temperature sensor using both single-ended and differential pair measurements from signals on the I2C bus. The primary focus is on differential measurement and how it results in a more accurate signal.

Single-Ended vs. Differential Measurement– baseline

- We measure the sensor readings of the TMP36 using both single-ended and differential method. Even though there is a long path between the TMP36 and ADS1115 local grounds, the sensor voltage is measured as ~740mV in both methods. We see less than 1mV of noise in each reading
- The reason there is no voltage drop in this path between the TMP36 local ground and the ADS1115 local ground is because there is normally less than 1 mA of current flowing through this ~0.04 ohm path. 1 mA x 0.04 A = 40 uV of drop



Single Ended (Orange)
vs.
Differential (Green) Measurements

As seen, both measurements are the same because we have no noise in our return path.

Adding Ground Noise With a Function Generator

- Supplying a 1 Hz square wave of 200mA peak to peak current into the return path, also knowing our trace resistance of our return path is 0.04 Ohms,
- We expect to see V = IR = .2(.04) = 20 mV peak-to-peak voltage noise on the single ended measurement, and expect to see that the differential measurement is entirely insensitive to this noise.

As expected, we see ~15mV of noise in the SE measurement, and none in the differential.

Conclusion & Takeaways

- When our return path has noise, a differential measurement is always preferred, as the voltage difference is referenced between two inputs.
- In single ended measurements, we measure the voltage in reference to ground. If our ground (return path) fluctuates due to ground noise, inductance, current injection, etc. then these fluctuations will appear on our measured signal.
  - Differential pairs improve noise immunity and signal integrity.
  - Ground noise is a major factor in single-ended measurements.

- In a differential measurement, the noise is taken out and only the true signal remains. Moving forward, this will be of extreme importance when measuring a high-speed precise signal.