Investigating the Performance of an Aircraft Mechanical Altimeter

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Objectives

- Construct plumbing system for aircraft mechanical altimeter and MPX5100AP absolute pressure sensor to simulate altitude pressure.
- Design electrical circuit using INA114AP instrumentation amplifier to scale output voltage of pressure sensor to feet of altitude.
- Evaluate the performance of the altimeter by taking readings of the two devices across a range of pressure equivalent to 0 to 5000 feet of altitude.

Figure 1: The mechanical altimeter.

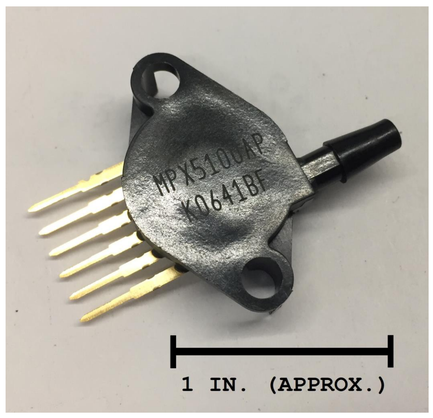

Figure 2: The pressure sensor.

Methods

The altimeter and pressure sensor, shown in Figure 1 and Figure 2, respectively, were connected to a hand pump in parallel using clear plastic tubing. The connections were made using barbed plastic fittings.

The unadjusted output voltage was recorded at every 100 feet, according to the altimeter, as the pressure in the system was lowered and then raised. This data was averaged and is shown in Figure 5. This was plotted to find the rate at which the unadjusted output voltage was changing with respect to altitude. The gain resistance of the instrumentation amplifier was set so that the adjusted output voltage of the pressure sensor would read 1 volt for every 1000 feet of altitude. The circuit, shown in Figure 3 and Figure 4, was also configured using a potentiometer so that the readings of the adjusted output voltage and the altimeter were equal at 2500 feet—the halfway point of the test pressure range. With the output voltage correctly scaled, readings were taken as the pressure was lowered and then raised. The average of the data is plotted in Figure 6.

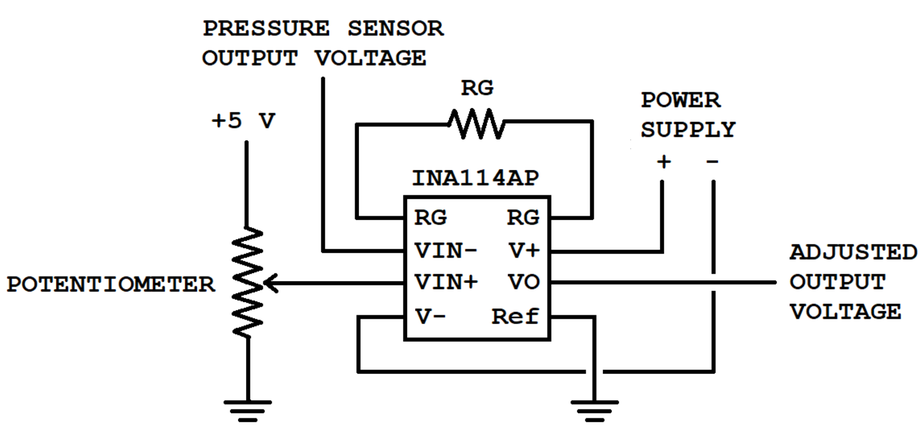

Figure 3: Schematic of the circuit used to scale the output voltage of the pressure sensor.

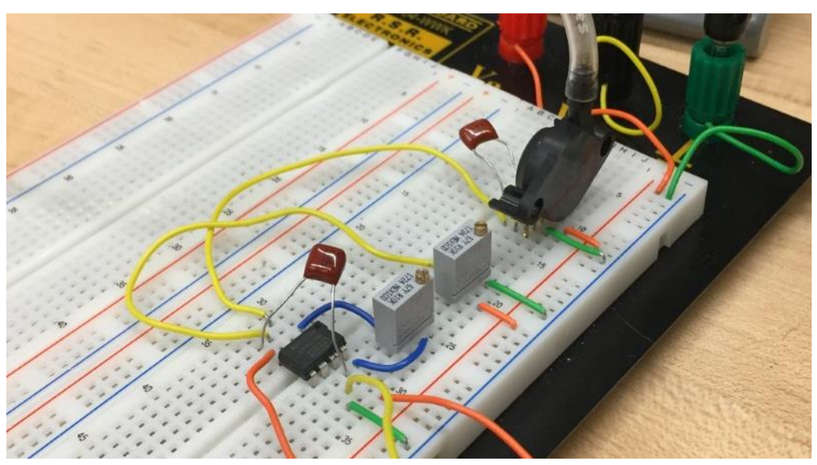

Figure 4: The prototype of the circuit.

Results

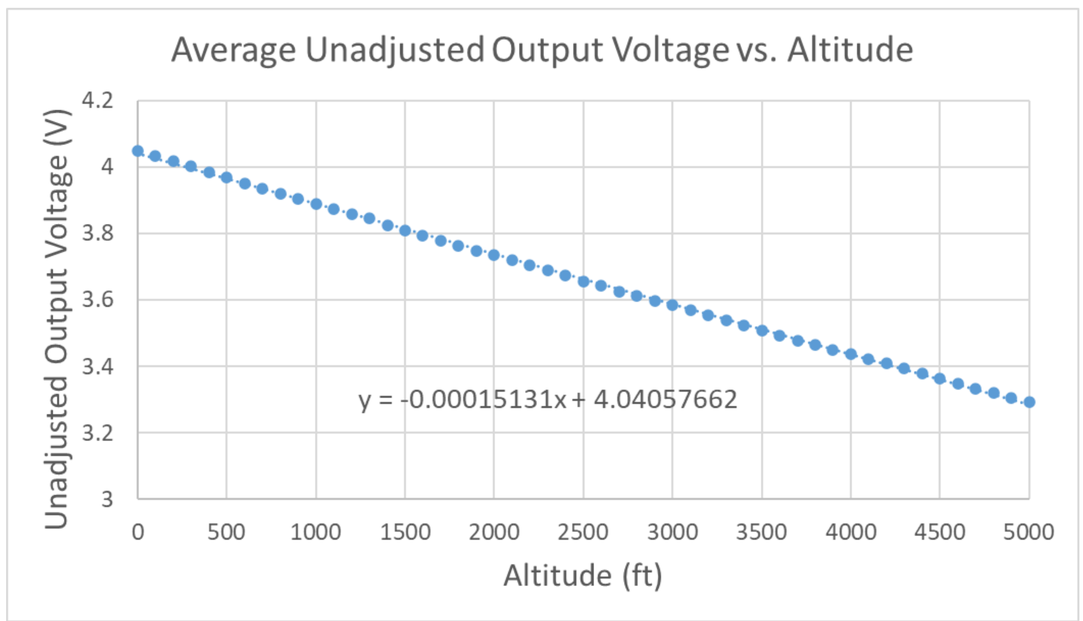

Figure 5: This plot shows the average unadjusted output voltage of the pressure sensor with respect to altitude read by the altimeter. The equation represents the trendline of the data.

Figure 5 shows that the unadjusted output voltage of the pressure sensor decreased as the altitude read by the altimeter increased. The rate at which the voltage changed was 0.00015131 volts for every foot of altitude.

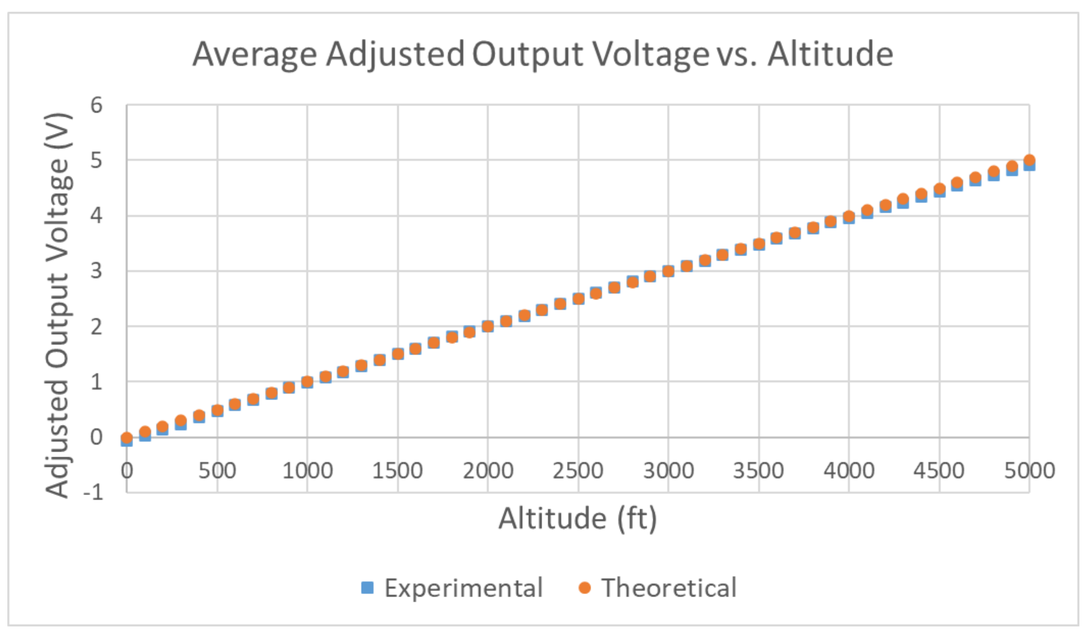

Figure 6: This shows the average adjusted output voltage of the pressure sensor with respect to altitude read by the altimeter.

In Figure 6, the adjusted output voltage of the pressure sensor closely matches the reading of the altimeter. Both change at approximately the same rate. There is a slight deviation in linearity between the two instruments, which can be seen at the ends of the pressure range.

Conclusions

Overall, the results in Figure 6 show that the altimeter is performing well relative to the pressure sensor. The data suggests that the altimeter may experience some linearity error, but this is made under the assumption that the pressure sensor is ideal. Setting the adjusted output voltage and the altimeter reading equal at 2500 feet helped to minimize the effects of the linearity error.

Hysteresis error in the altimeter was evident in that the dial hand would briefly “stick” when the direction of the pressure change was switched. Taking the average of the data reduced the effects of this on the experiment results. Considering that the altimeter’s usual operating environment is exposed to vibrations, this hysteresis error may not pose a significant concern when used in aircraft.