Linearized Force Sensor

So I just finished fall semester of senior year. One more semester to go then I have a Bachelor's of Science in Electrical Engineering! Anyway, I worked on a lot of projects this semester. When I said a lot I mean A LOT! Consider this plethora of projects as content that you guys can learn from. Anyway, here's one of the few projects I worked on this semester: a linearized force sensor.

So, there's this class at RPI called Capstone, a senior design class. I did not take the class, but several of friends took the class this semester. One of my friends' project was to create a data retrieval system to determine if a person fell over. One day, my friend asked me to take a look at the foot sensor for the system. Right off the bat, I saw an immediate problem with the circuit: the circuit's output will be non-linear.

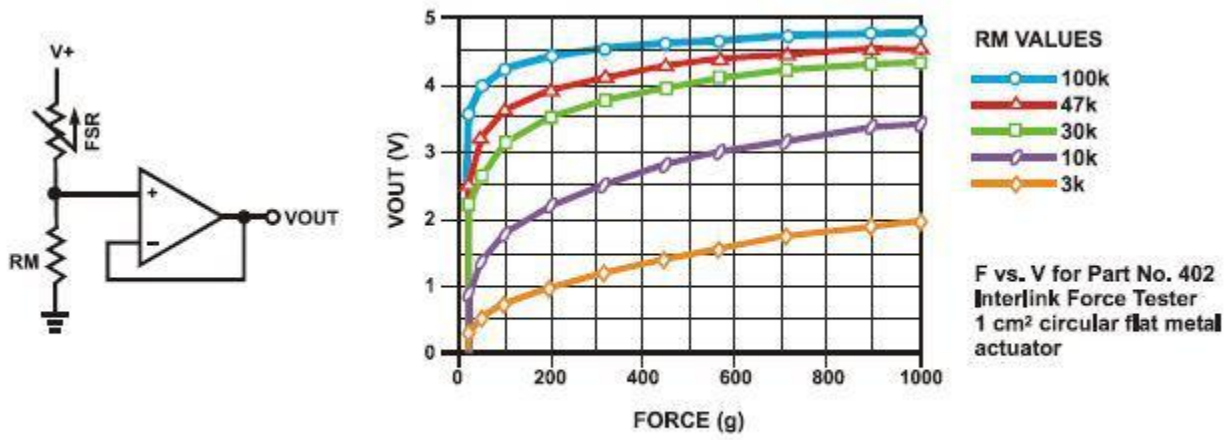
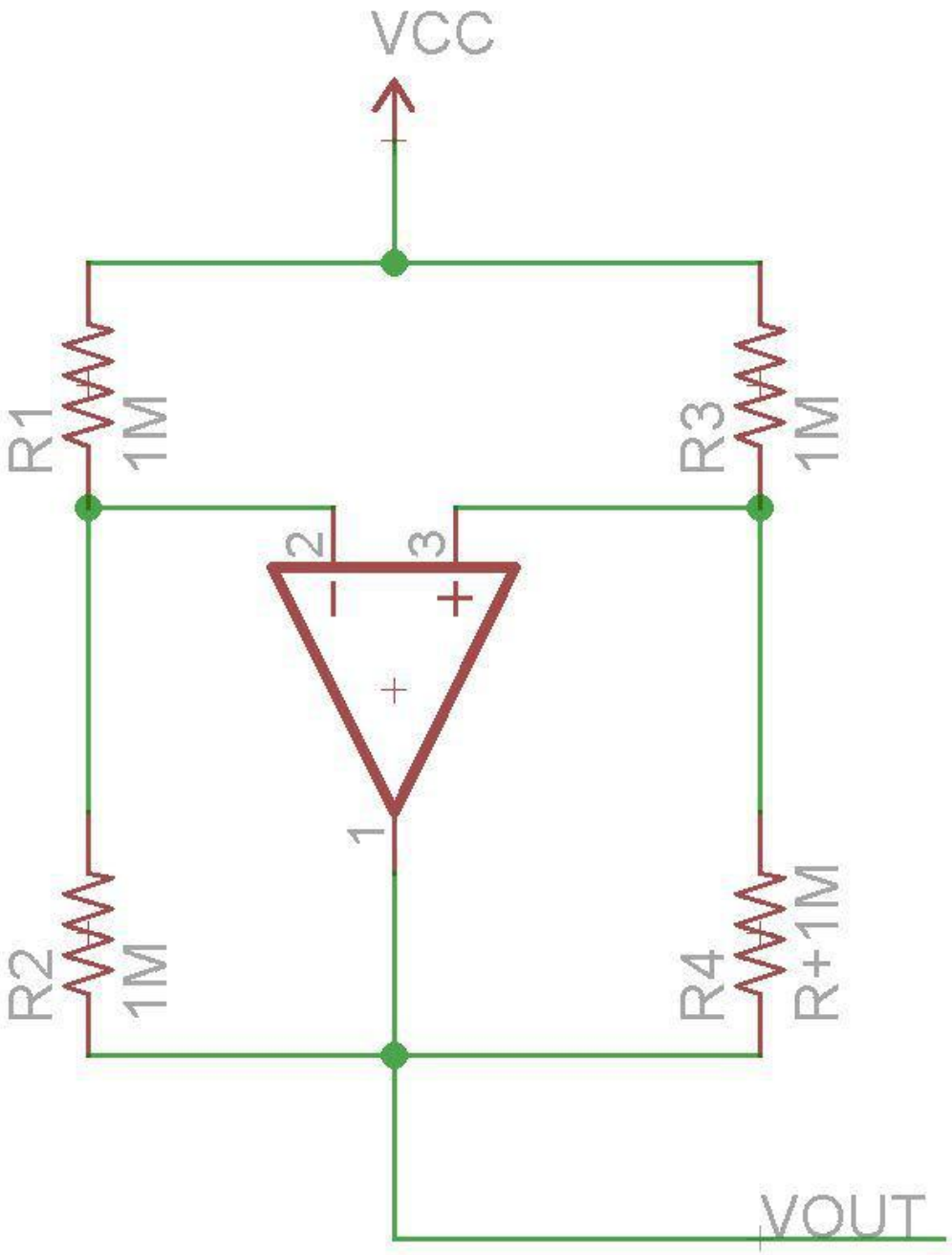


Figure 9
FSR Voltage Divider

The circuit that my friend used, is shown in the figure, which was taken from the datasheet of the force sensor, above. For both 3k to100k RM values, the force is almost linear. However, after that, the output will be constant. Why is this a problem? When it hit's the non-linear region, it becomes very difficult calculating the force the sensor experiences. Also, when the sensor enter's the non-linear region, it tends to oversaturate the op-amp, or the output of the op-amp will be at +vdd or -vdd. Don't believe me? Here's the output voltage of the circuit.

$$V_{out} = \frac{V_{dc}}{1 + \frac{R_{FSR}}{R_M}}$$

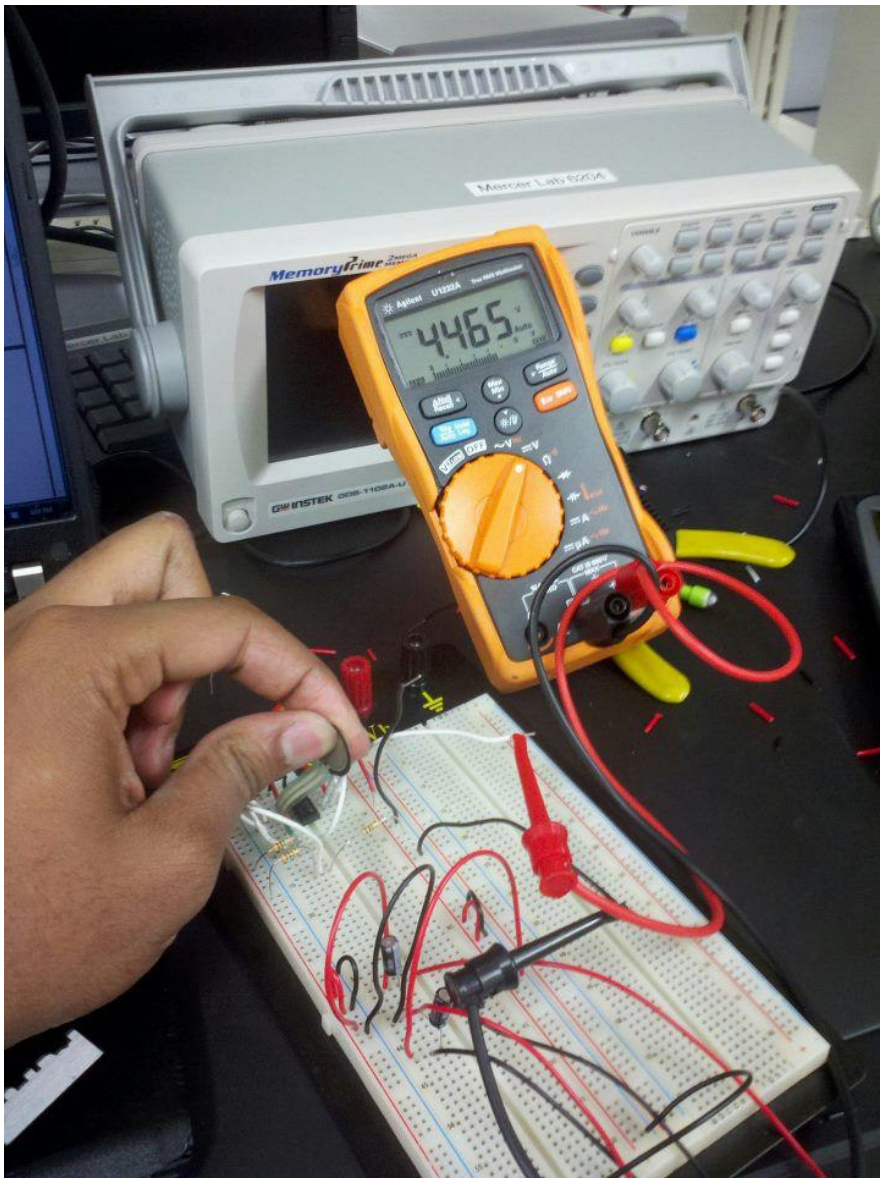
As shown above, as RFSR decreases, the output voltage will increase as well. Unfortunately, there will be a point where the output voltage will stay constant as shown in the graph previously. In fact, my friend encountered this issue constantly during testing. They were applying as much force as they could to the sensor, but the value never changed. So, how did I linearized the output? I connected the force sensor to what we call a bridge circuit, which I remembered from my Advanced Electronics course that I took spring 2012.



The figure above shows the linearized circuit, where the force sensor is represented as R4, which value is change in R+1M. I won't go over the analysis, but I will show you the equation of the non-linearized circuit, and the linearized circuit. The equation below shows how the resistance of the force sensor will affect the output voltage of the circuit.

$$V_{out} = V_{dc}\frac{\Delta R}{2R}$$

The picture below shows my implementation of the circuit on a breadboard. Although I had a 15v power supply at the time, I added two 10 microfard capacitors in series to create a dual 10v supply power supply for the op amp. The place where the force is measured is located at the circle of the force sensor. When I varied the pressure applied to the circle, it changed from 2.3V to 4.5V perfectly.



The only problem with the circuit is relating force to the force sensor's change of resistance. I still need to get to that.Despite my efforts to show my friend that if they

stick with their non-linear circuit he would encounter nothing but trouble, he still went with the non-linear circuit. Why? Because the professor didn't want to change the circuit. The professor knew perfectly well that the output of the circuit will be non-linear, but still wanted to stick with it. The worse part is that he wanted to work in the non-linear region. Oh well.

Source: http://coolcapengineer.wordpress.com/2012/12/17/projects-linearized-force-sensor/