MAS.836
LABORATORY THREE

Introduction to Force Sensitive Resistors and Piezo Films:
The purpose of this laboratory exercise is to familiarize yourself with the implementation of FSR and piezo amplifiers. Both have specific amplifier requirements due to their high source resistance. The FSR can be particularly difficult as it has a non-linear response to the applied force. Again, you will construct your circuit from the parts given in the laboratory kit, and any resistors, capacitors, and diodes you may need from the RESENV stock area. You will also need to turn in your functioning kit on your signed protoboard, and turn in a report detailing the design you chose, answering any questions given in the laboratory assignment, and plotting any performance criterion asked for in the laboratory assignment. Both of these things will be collected directly after class on the due date.

It is important to be careful with your FSR. Both the crimped leads and the sensing element can be quite fragile. When applying force to your FSR, do not press diagonally, or create a shear force on the device. The material can be damaged under shear, so always press directly down into the FSR.

Problem One: FSR amplifier construction

Before beginning your amplifier design, please look at the FSR datasheet linked off of the class website. From these information you will be able to select initial gain values for your amplifier. Note that the force versus resistance characteristics of the FSR are not linear. In many applications you will be interested in having a linear voltage response to an applied input force. Problem Set Three covered one technique for linearizing a non-linear response, but you are welcome to use any method of your choosing; just keep in mind that the entire laboratory assignment must be completed with the single, quad op-amp package.

The FSR included in your kit is one of the smallest ones made, although they can come in any size which you may choose to design. But, for small runs, where it is not cost effective to have your own design made, there are still a variety of sizes to choose from. The FSR is generally not very accurate, repeatable, or robust, and it is mildly expensive at 6$ a sensor. But, it makes up for this with ease of use, and being relatively inexpensive and small in size with respect to other force sensing elements such as load cells.

In this assignment, you will design an FSR amplifier that gives a linear zero to five volt output for a linear input of zero to one kgf on the FSR. Since you will not have a method for measuring the input force, just estimate the force you are applying, keeping in mind that one kgf is approximately the force produced by one finger being pressed down relatively hard. To demonstrate the output voltage increasing with increasing forces, place an LED in your circuit so that it become brighter as the force increases.

The brightness of an LED is approximately proportional to the current which passes through it. If an LED has a resistor in series with it, and if the voltage drop across the LED is small compared to the total voltage applied, the current will be proportional to the applied voltage, as the resistor will make a linear voltage to current source. Therefore, for the purposes of this laboratory, merely placing a resistor and LED at the output of your circuit will suffice. A reasonable maximum current to run through an LED is 20mA, although your op-amp may have trouble sourcing this much current. The LEDs given in the kit can produce a significant amount of light at less than 5mA.

Questions:
1. What is the maximum voltage the TLV2374 can reach if it is at room temperature, sourcing 20mA, and running from a single 5V supply.
2. What is the voltage drop across the LED in your kit when it is on?
3. What is the resistance across your FSR with the maximal force applied?

Problem Two: Piezo film amplifier construction

The piezo film included in your laboratory kit is an inexpensive (one dollar) way of measuring vibration, and comes in a relatively small package (the film itself is 28µm thick, 15mm long, and 10mm wide). It is not as small, repeatable, or as accurate as a MEMS accelerometer, but is one-twentieth the cost. This makes it a good candidate for picking up general motion where accuracy is not a concern. The piezo film requires a buffer amplifier to ensure that its high source impedance does not degrade its output. For this reason, the op-amp in your kit has an extremely low input bias current, on the order of 1pA.

In this assignment, you will design a piezo peak wind speed detector which outputs a digital pulse when peak wind speed is reached, and a clean analog voltage signal which is proportional to the amplitude of the input wind speed (which causes a vibration in the piezo film). The output voltage should go from zero to five volts under maximum wind speed, and have a clean and stable signal that could be sampled by an ADC without noise. A second output should create a zero to five volt pulse when the piezo film reaches its maximum vibraton, which would be used to signal the ADC to take its sample. The exact ratio of input speed to output voltage is not critical, as this could ultimately be calibrated out with a look-up table. Again, connect the output to an LED so you can see the intensity change with input amplitude. Place the piezo film vertically in your protoboard and blow on it to generate the wind vibration. Assume the ADC has an input impedance of 1Megohm.

Questions:
1. What is the dominant frequency your piezo element produces under stimulus?
2. What is the capacitance of your piezo element?
3. What size load resistor should you put on your piezo element to filter out frequencies below the dominant frequency?