BME310

12 - Sensors

Homework

1. A load cell uses a Wheatstone Bridge and an OpAmp to measure the force on the knee of a person using an exoskeleton. What should the gain of the amplifier be to yield an output voltage between -10 and + 10 volts measuring 0.5 − 10 Newtons. Assume that the Wheatstone Bridge is powered with 10 volts has a sensitivity of 50mV/V/Newton

$$50mV / V / Newton \times (10V) \times (0.5N) = 0.25 \Rightarrow A = \frac{10}{0.25} = 40$$

$$50mV / V / Newton \times (10V) \times (10N) = 5V \Rightarrow A = \frac{10}{5} = 2$$

If we choose $A = 40$, then the output will be $(50 \times 10^{-3} \times 10 \times 0.5 \times 40 =)$ 10 to $(50 \times 10^{-3} \times 10 \times 10 \times 40 =)$ 200 volts

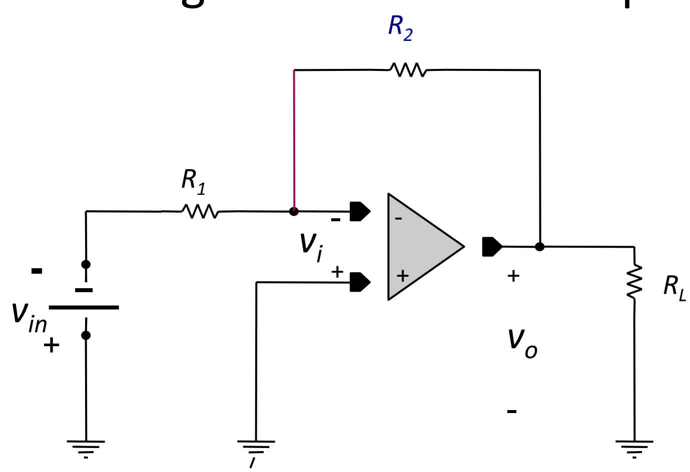
If we choose $A = 2$, then the output will be $(50 \times 10^{-3} \times 10 \times 0.5 \times 2 =)$ 0.5 to $(50 \times 10^{-3} \times 10 \times 10 \times 2 =)$ 10 volts

Choose $A = 2$

Homework

2. You have place a force sensor in a shoe and want to measure the weight of a object a person is carrying. What sort of amplifier should you use. Assume the force sensor is a variable resistor. Draw the circuit diagram and show where the force sensor is placed in the circuit. Explain how you circuit will work.

Use a inverting op amp and place the sensor as R1. Since the gain of an inverting op amp is −R2/R1, the with no pressure the output is zero. As the pressure is applied, then R1 reduces and the gain is non zero. Feeding the sensor with a negative voltage will make the output positive.



Homework

3. HONORS STUDENTS ADD THE FOLLOWING

Research and describe how resistors can be used in Wheatstone bridge configuration as a strain gauge. Draw the strain gauge Wheatstone bridge circuit and calculate the bridge voltage under the cases of tension and compression.

The resistance of a resistance can be modelled as

$R = \dfrac{\rho L}{A}$; where L is its length, A is its cross sectional area and ρ is the resistivity of the material.

In tension, the resistance changes

$R = \dfrac{\rho L + \Delta L}{A - \Delta A}$; where ΔL is the increase in length and ΔA is the decrease in area.

Note that this yields a net increase in resistance, h, $R + h$.

In compression, the resistance changes

$R = \dfrac{\rho L - \Delta L}{A + \Delta A}$; where ΔL is the decrease in length and ΔA is the increase in area.

Note that this yields a net decrease in resistance, h, $R - h$.

Homework

3. HONORS STUDENTS ADD THE FOLLOWING

Research and describe how resistors can be used in Wheatstone bridge configuration as a strain gauge. Draw the strain gauge Wheatstone bridge circuit and calculate the bridge voltage under the cases of tension and compression.

Take 2 resistors in the opposite postions, r_A and r_D, are placed so that they both increase in resistance when under tension and decrease in resistance under compression.

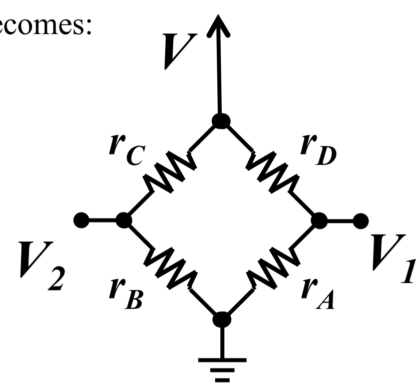
Take the other 2 resistors in the opposite postions, r_B and r_C, are placed so that they both increase in resistance when under tension and decrease in resistance under compression.

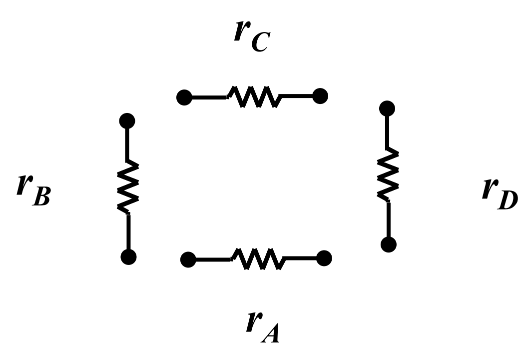
However the placement is such that when r_A and r_D are in tension the others r_B and r_C are in compression and visa versa.

Furthermore, assume that all 4 resistors have the nominal value R.

Therefore the bridge voltage becomes:

$$V_2 - V_1 = V\left(\frac{r_B}{r_B + r_C} - \frac{r_A}{r_A + r_D}\right)$$





Homework

3. HONORS STUDENTS ADD THE FOLLOWING

Research and describe how resistors can be used in Wheatstone bridge configuration as a strain gauge. Draw the strain gauge Wheatstone bridge circuit and calculate the bridge voltage under the cases of tension and compression.

Under ideal conditions, the bridge voltage is:

$$V_2 - V_1 = V(\frac{r_B}{r_B + r_C} - \frac{r_A}{r_A + r_D}) = V(\frac{R}{2R} - \frac{R}{2R}) = 0$$

When $r_B = R + h$ and $r_D = R + h$ are under tension, then $r_A = R - h$ and $r_C = R - h$ are under compression.

Under this case, the bridge voltage is:

$$V_2 - V_1 = V(\frac{r_B}{r_B + r_C} - \frac{r_A}{r_A + r_D}) = V(\frac{R+h}{R+h+R-h} - \frac{R-h}{R-h+R+h}) = V(\frac{R+h}{2R} - \frac{R-h}{2R})$$

$$= V(\frac{R+h-(R-h)}{2R}) = V(\frac{h}{R})$$

And when these resistors are under compression:

$$V_2 - V_1 = \frac{R-h-(R+h)}{2R}) = -V(\frac{h}{R})$$