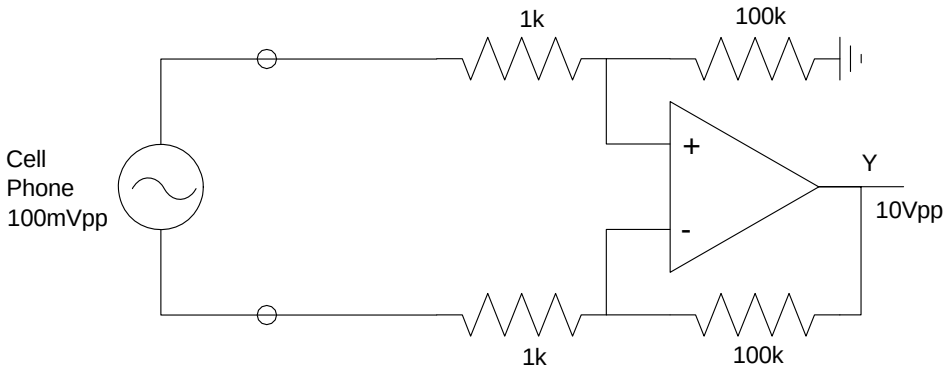
ECE 321 - Homework #2

Audio Sensors, Strain Gages, Calibration and Noise. Due Monday, November 18th

Audio Sensors:

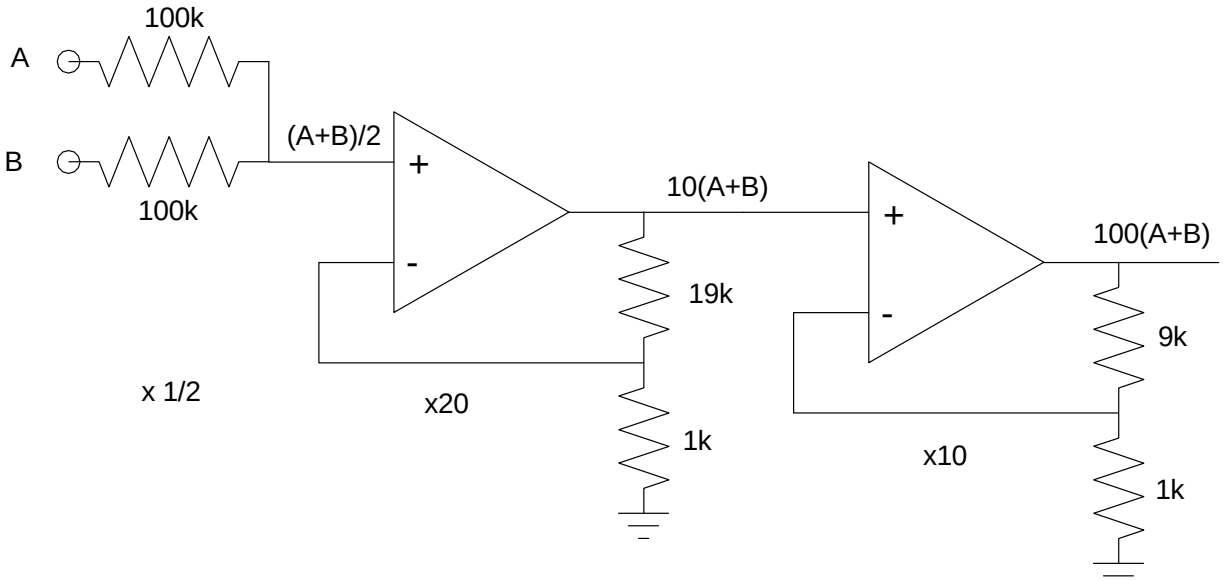
1) Assume the voltage from the headphone jack of your cell phone is a 100mVpp audio signal. Design a circuit to amplify this signal to 10Vpp.

Other circuits work - this keeps the noise down by amplifying the difference between the two wires



2) Design a circuit which will mix two audio signals (each 100mVpp) and output a 10Vpp signal

- A = 100mVpp
- B = 100mVpp
- Y = 100(A + B)



Other circuits also work

Strain Gages

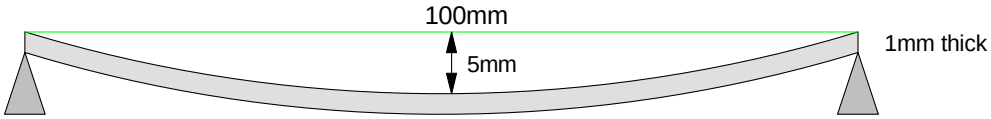
3) Assume a strain sensor has a strain - resistance relationship of

$$R = 120(1 + 2.14\varepsilon)$$

Design a circuit which outputs

- 0V for a force of 0N (0lb), and
- 10V for a force of 100N (22.4lb)

Assume a force of 100N causes the beam to deflect 5mm



First, find the radius

$$R^2 = (R - 5)^2 + 50^2$$

$$R = 252.5mm$$

Assuming the center line has zero strain, the strain is then

Inside Edge:

$$\varepsilon = \left(\frac{-0.5mm}{252.5mm}\right) = -0.001980$$

Outer Edge

$$\varepsilon = \left(\frac{+0.5mm}{252.5mm}\right) = +0.001980$$

A strain gage placed on the inside edge will have a resistance of

$$R = 120(1 + 2.14\varepsilon) = 120.0508\Omega$$

$$R = 120 \cdot (1 + 2.14\varepsilon) = 119.4915\Omega$$

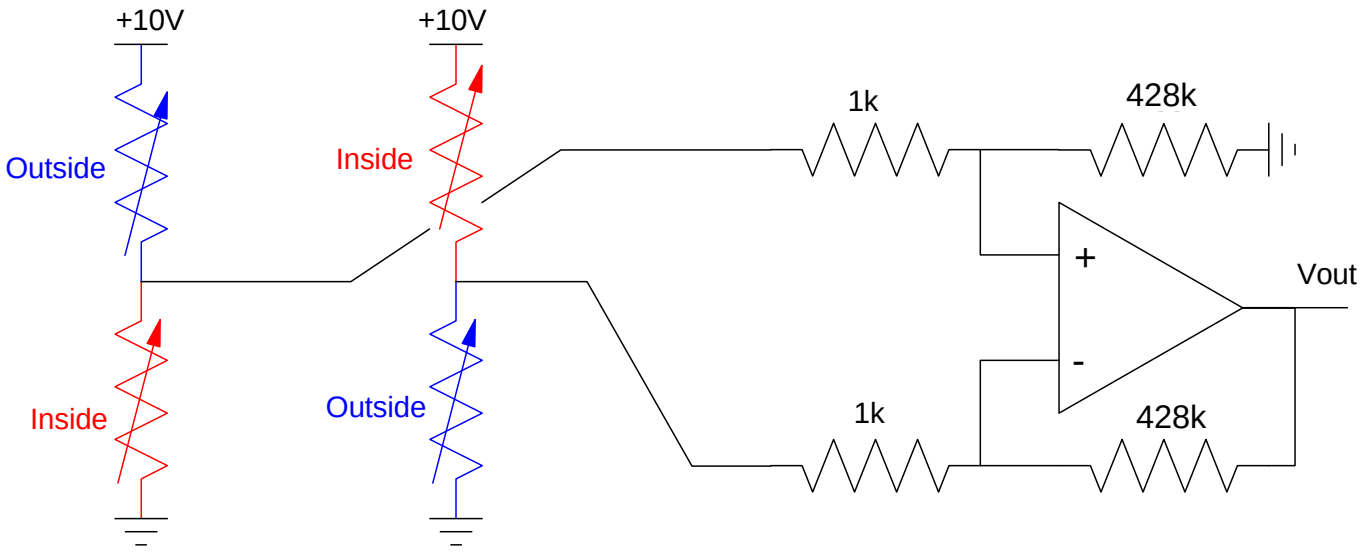
Use four strain gages to compensate for temperature and amplify the difference. The voltages are then

$$V_a = \left(\frac{120.0508}{120.0508+119.4915}\right) 10V = 5.0117V$$

$$V_b = \left(\frac{119.4915}{120.0508+119.4915}\right) 10V = 4.9883V$$

The gain required is

$$gain = \left(\frac{10V-0V}{5.0117V-4.9883V}\right) = 428.3$$


+10V
+10V
Outside
Inside
Inside
Outside
1k
428k
1k
428k
+
-
Vout

Calibration

4) Determine an approximation for

$$y = \sin(x)$$

for 0 < X < 1 as

$$y \approx a + bx + cx^2 + dx^3$$

In Matlab (actually SciLab)

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x = [0:0.001:1]';
y = sin(x);

B = [x.^0, x, x.^2, x.^3];

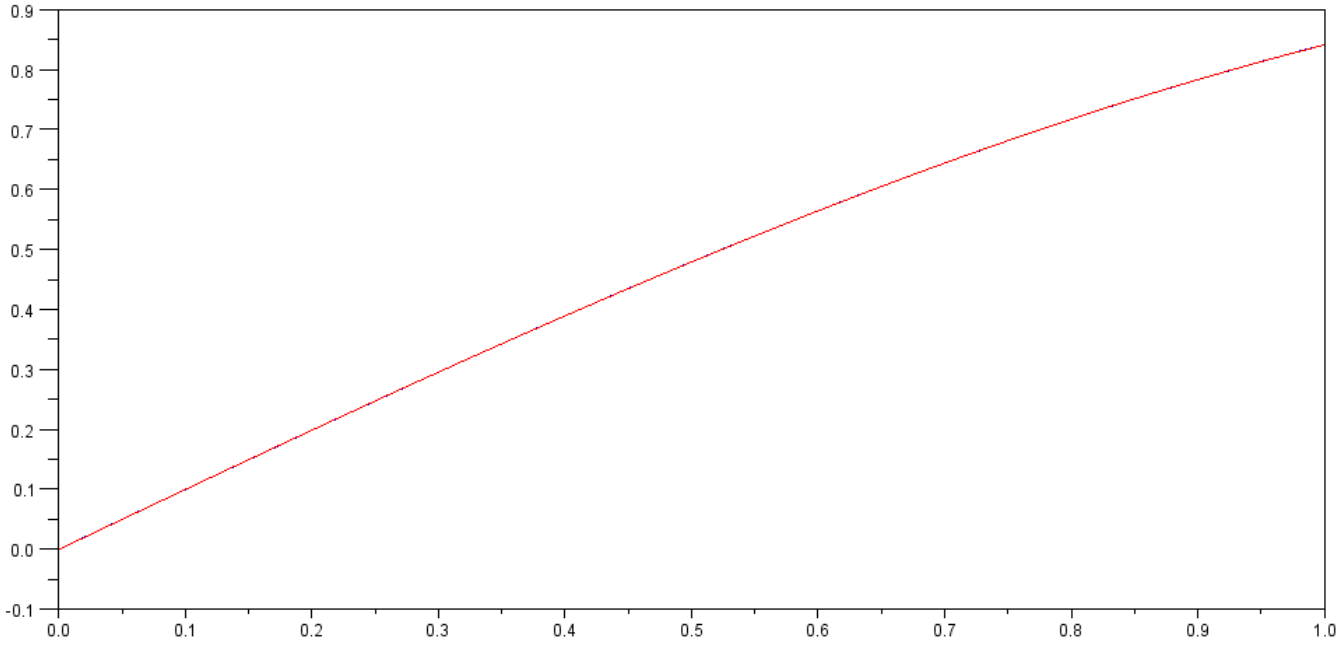
A = inv(B'*B)*B'*x

  -0.0002513
   1.0047476
  -0.0190936
  -0.1442398

plot(x,y,x,B*A)
```

meaning

$$y \approx -0.00025 + 1.00474x - 0.01908x^2 - 0.14424x^3$$



y = sin(x) (blue) and it's cubit approximation (red)

ECE 321 Project: Section (1)

Cell Phone Amplifier

Problem 5) Specify the requirements for an amplifier circuit.

Input: Cell Phone audio jack

- 0.1Vpp sine wave
- 20 - 1kHz (so you have something to test)
- Capable of driving 10mA

Output:

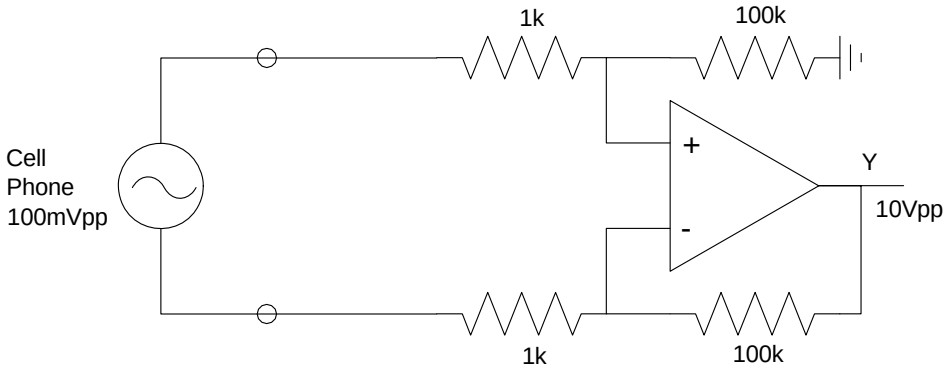
- 10Vpp sine wave
- 20 - 1kHz
- Capable of driving 10mA

Tolerance:

- +/- 10% in gain

Note: You need numbers so you have something to design to.

Problem 6) Design a circuit to meet these requirements.



Problem 7) Build your circuit in lab and verify it operates correctly. Check the endpoints and one or two points inbeweeen.

Check the two endpoints

- Gain at 20Hz
- Gain at 1kHz

Check one or two points in between

- Gain at 100Hz
- Gain at 300Hz

Problem 8) Demo. Demonstrate your amplifier

Note: Save your circuit. You'll use it again in the following homework sets