NAME (please print) ______________________________ SID __________________

UNIVERSITY OF CALIFORNIA, BERKELEY
Electrical Engineering and Computer Sciences Department

EECS 145L Electronic Transducer Lab
MIDTERM #2 (100 points maximum)
November 18, 2009

(closed book, calculators OK, equation sheet provided)
(You will not receive full credit if you do not show your work)

PROBLEM 1 (40 points)

For each of the sensors below describe their construction and how they produce their output signal.

1.1 Digital encoder (optical, for measuring angle) (5 points)

1.2 Bimetal switch (5 points)

1.3 Platinum resistance thermometer (5 points)

1.4 Thermistor (5 points)

1.5 Thermocouple (5 points)

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1.6 PIN photodiode (5 points)

1.7 Metal film strain gauge (5 points)

1.8 Ag(AgCl) electrode (5 points)

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PROBLEM 2 (30 points)

Many older bridges contain long, flat steel bars (eyebars) that have holes (eyes) at their ends for attachment. These bridges have been known to fail when a crack in the steel around one eye gradually widens and transfers too much stress to the parallel eyebars. One of the most famous examples is the Silver Bridge on the Ohio river that collapsed in 1967 with the loss of 46 people. The San Francisco Bay Bridge has also developed such a crack in one of its eyebars.

Design a circuit for measuring the strain at a particular location with the following requirements:

- Use metal film strain gauges with 100 ohm resistance and a gauge factor of 2
- Output voltage 1 V for a strain $\Delta L/L = 0.1\%$
- The output must be minimally affected by temperature changes. The thermal expansion coefficient for steel is 11 ppm/C so that possible temperature changes from -5C to +40C could produce dimensional changes of $\Delta L/L = 500$ ppm or 0.05%.
- Minimal number of active circuit components

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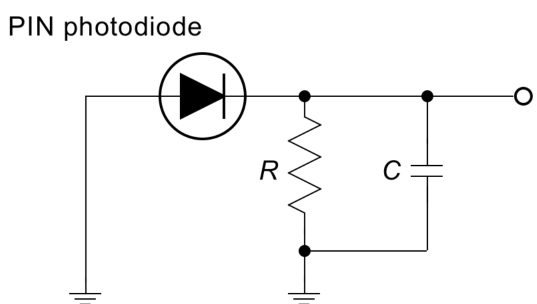
PROBLEM 3 (30 points)
One way of detecting small planets orbiting nearby stars is to measure the decrease in the brightness of the star when the planet periodically passes in front of the star.
Assume the following

- You have a telescope that automatically tracks a nearby star so that its image stays focused on a PIN photodiode
- The photocurrent produced in the diode by the star is 1 nA.

3.1 (6 points)
Add additional circuits to the circuit below to produce an output voltage of 1V per nA of photodiode current for $R = 1\ \text{M}\Omega$ ($C = 0$).



3.2 (6 points)
For $R = 1\ \text{M}\Omega$, what value of C gives an RC filter bandwidth $\Delta f = 1$ Hz?

3.3 (6 points)
With a bandwidth of 1 Hz, what is the rms Johnson noise of resistor R at the output of the full circuit in part 3.1 above?

3.4 (6 points)
What is the diameter d of a planet that would reduce the detected signal from a star of diameter D by an amount equal to five times the Johnson noise of resistor R? (Note: for the earth and sun $d/D = 9.2 \times 10^{-3}$)

3.5 (6 points)
How much better could you do in detecting small planets by taking and averaging 100 measurements?