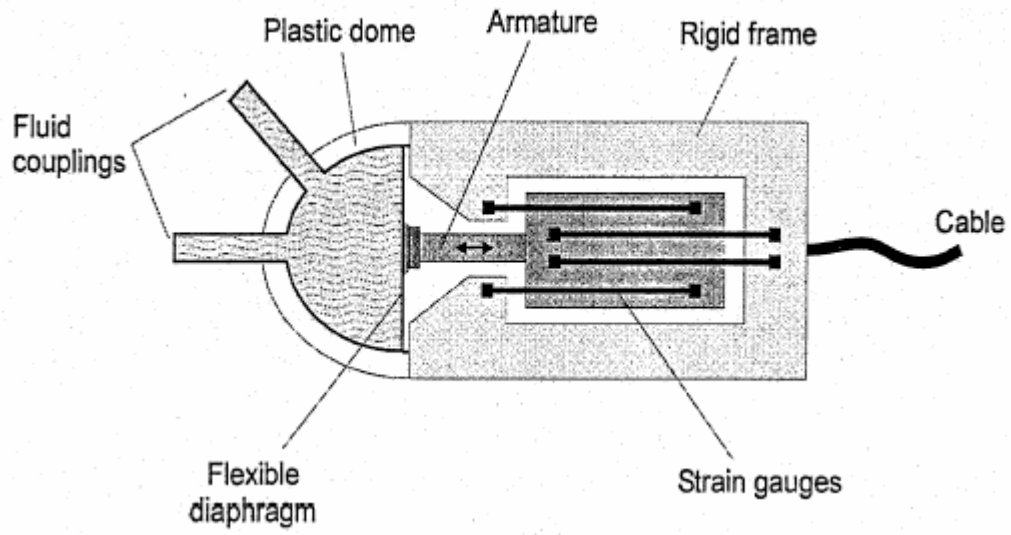
Instrumentation – exercise

Assume we want to design an instrument to measure the fluid pressure through the displacement of a strain gauge sensor



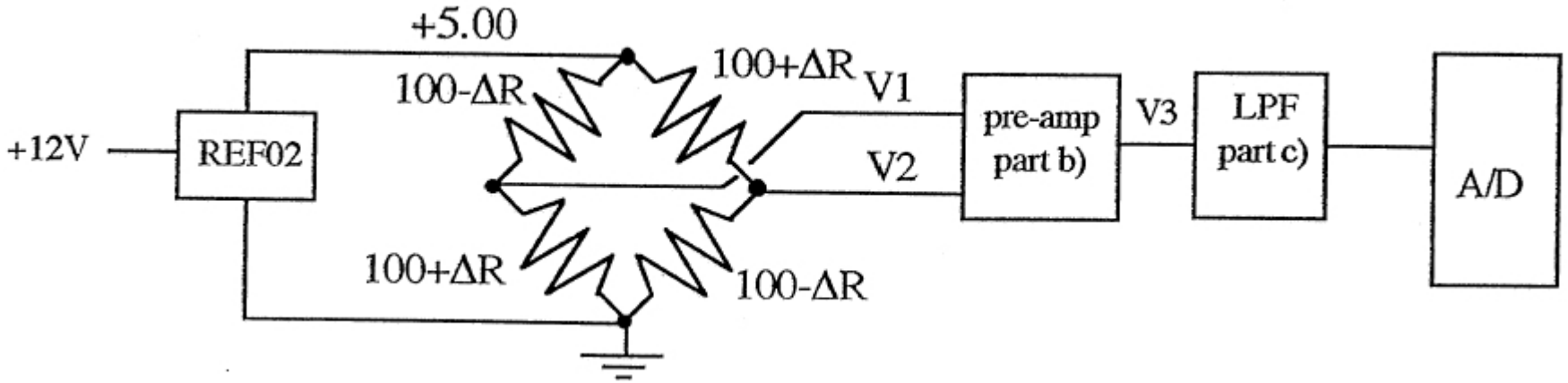
Recall that the strain gauge converts changes in displacement into changes in resistance

Gauge factor $$G = \frac{\Delta R / R}{\Delta l / l}$$

Circuit design

We will use a bridge circuit to convert resistance to voltage signals.

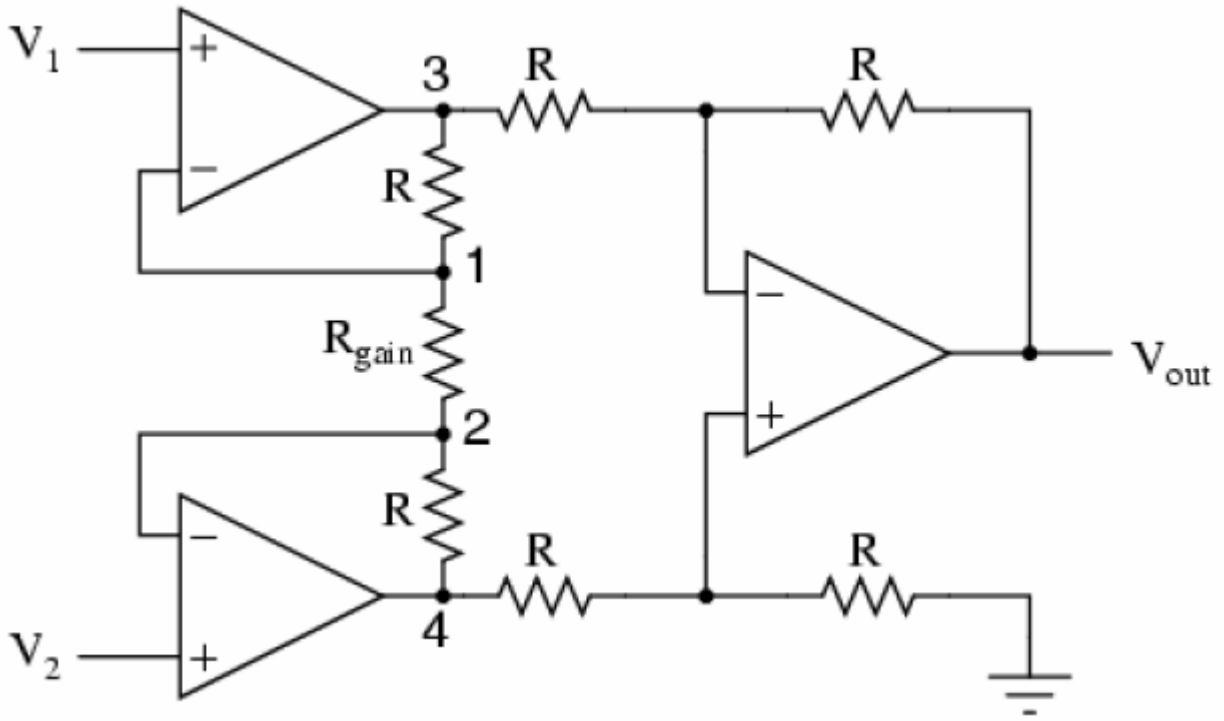
Consider the following circuit diagram



And the following specifications of the system

- The maximum change in ΔR is $\pm 1\Omega$
- The A/D has range of $\pm 5V$ and a 16-bits resolution
- The signal of interest has frequency components in the range of 0-100 Hz

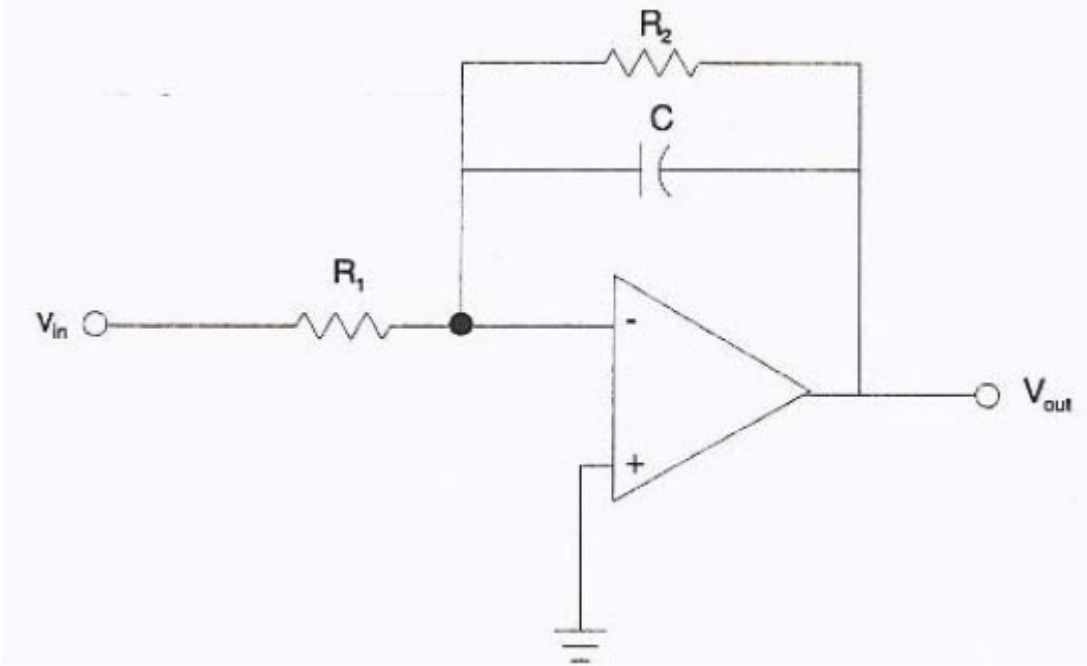
Pre-amplifier

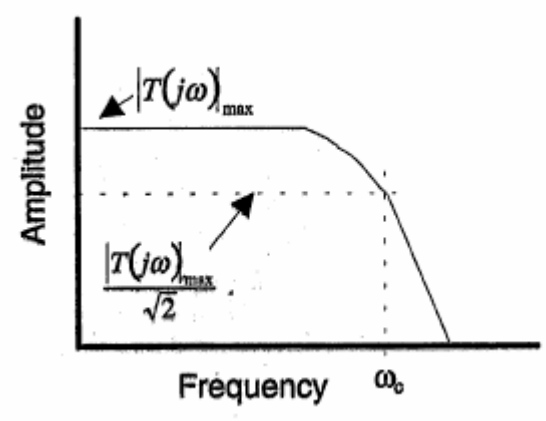


For the instrumentation amplifier AD620, 2R = 49.4 kΩ

$$Gain = 1 + \frac{2R}{R_{gain}}$$

Low-pass filter





$$f_c = \frac{1}{2\pi R_2 C} \qquad \text{Gain} = -\frac{R_2}{R_1}$$

Introduction to Biomedical Engineering

1st semester, 2006-2007

Biomedical Optics

1. What are the advantages and disadvantages of optical detection?
2. Spectroscopy: basic mechanism of absorption, fluorescence and Raman spectroscopy. Why spectroscopy can tell us information about molecules we are measuring? What is the relationship between the energy states of molecules and the wavelength of light?
3. Meaning of Beer-Lambert's law $\Rightarrow$ exponential decay of light with increasing path length.
4. Applications (some examples we mentioned in class) of optics in biomedical research, diagnosis and therapy.
5. What is photodynamic therapy? How does it work?

Bioelectric phenomena

1. Origin of resting membrane potential. The roles of the cytoplasm membrane, concentration of ions, ion channels, ion pumps, etc.
2. Qualitatively explain the meaning of the Goldman equation.
3. Mechanism of action potential. The roles of ions, ion channels, ion pumps, etc.
4. What is the refractory period and what is its importance?
5. Examples of electric signals of the human body. Explain the origin of ECG signal and its main physiological meaning.

Sensors/Instrumentation

1. Block diagram with the essential components of a biomedical instrument that measures signals from the human body.
2. Examples of transducers for physical measurements.
3. Basic components of a biosensor and their functions.
4. Bridge circuit. Input and output characteristics.
5. Ideal operational amplifiers and basic op-amp circuits.

6. Transfer functions and frequency responses of op-amp based filters with passive components (resistors, inductors, capacitors).
7. Properties of non-ideal op-amps.

Biosignal processing

1. Signal acquisition: quantization of the signal magnitude and sampling in time. Sampling theorem. Resolution of A/D hardware.
2. Tell the difference between continuous and discrete signals. Concept of discrete numbers as a result of sampling of a continuous signal.
3. Qualitatively describe the purpose of using Fourier transforms in biosignal processing.
4. What is the difference between infinite impulse response (IIR) filters and finite impulse response (FIR) filters?
5. What advantages do short-time Fourier transform and wavelet transform have over the conventional Fourier transform?
6. Describe the structure of artificial neural networks and the basic mathematical relationship between a neuron’s inputs and outputs.