King Saud University

College of Applied Medical Sciences

Biomedical Technology

BMT 313

Sample Exam

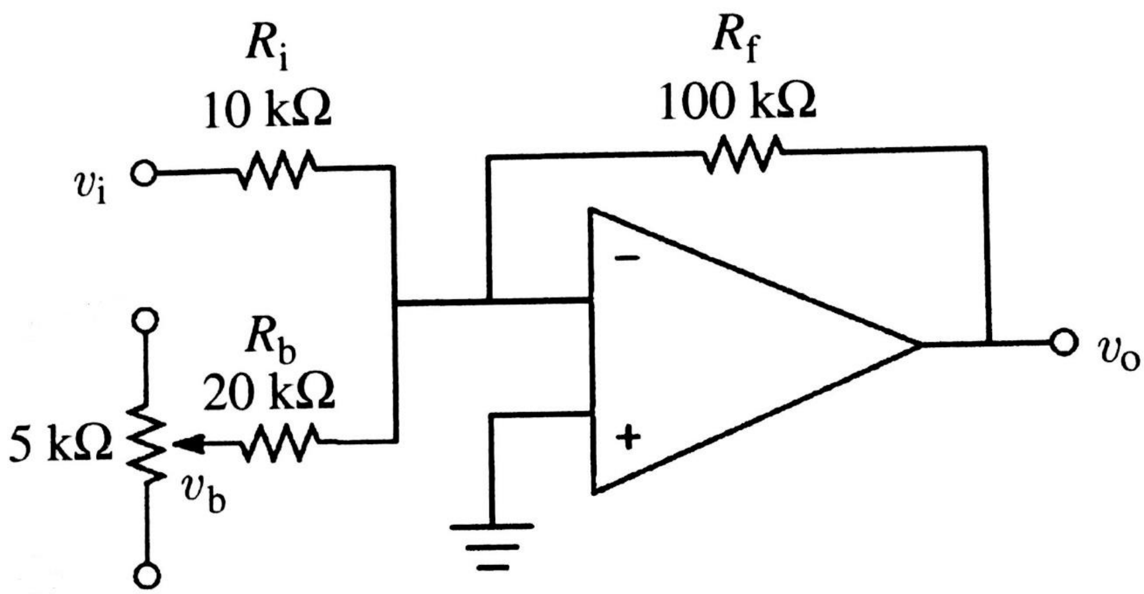
Inverting Amplifier

Q1: A biopotential preamplifier, used in an electromyogram circuit, has an undesired dc voltage of ±5 V due to unwanted interference, while the desired signal is ±1 V superimposed.

Design a circuit the will balance the dc voltage to zero and a gain of -10 for the desired signal without saturating the op amp.

Answer:

The figure below shows the proposed design. We assume that v_b, the balancing voltage available from the 5 kΩ potentiometer, is ±10 V.



The undesired voltage at v_i= 5 V. For v_o= 0 V, the current flowing through R_f should be zero.

Therefore, the sum of the currents through R_i and R_b is zero.

$$\frac{vi}{Ri} + \frac{vb}{Rb} = 0$$

$$Rb = Ri\frac{vb}{vi} = -\frac{10^4(-10)}{5}$$

$$Rb = 2\ \times 10^4\ \Omega$$

To obtain a gain of -10, R_f/R_i should equal 10 (i.e. R_f= 100 kΩ)

$$vo = -Rf\left(\frac{vi}{Ri} + \frac{vb}{Rb}\right)$$

$$vo = -10^5(\frac{vi}{10^4} + \frac{vb}{2\ \times 10^4})$$

$$vo = -10(vi + \frac{vb}{2})$$

One Op-Amp Differential Amplifier

Q2: A blood pressure uses a strain gage to monitor the blood pressure. The strain gage is composed of four active arms of Wheatstone bridge. This bridge is excited with 5 V dc, and each arm changes resistance by ±0.3%.

Design an amplifier that will provide a full-scale out over the op-amp's full range of linear operation, using the minimal number of components.

Answer:

The change in v_o of the bridge = $vi\frac{\Delta R}{R}$

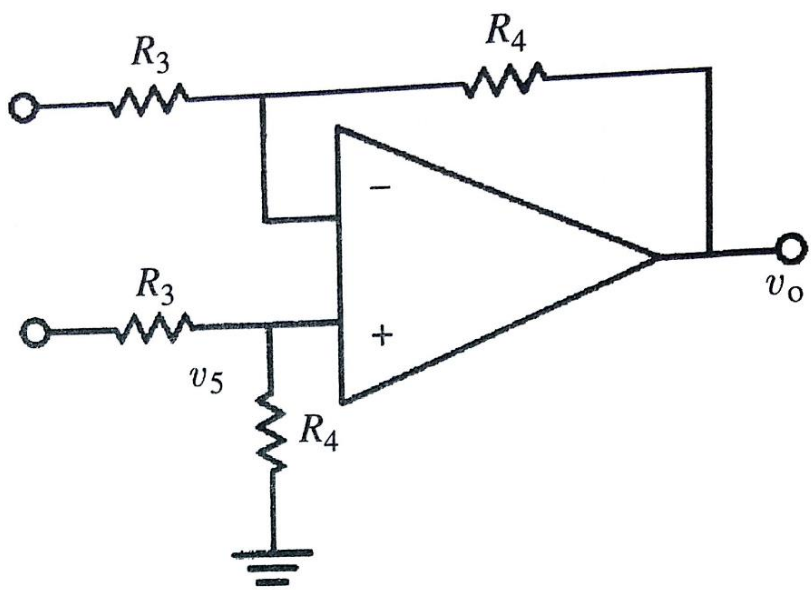
= (5 V) 0.003 = 0.015 V

Gain = 20/0.015 = 1333

To calculate the resistors values of the differential op-amp:

Assume R = 120 Ω

Then, the Thevenin source impedance = 60 Ω



We will use this value to replace R_3 (in the shown circuit).

Since the gain = R_4/R_3

R_4= (1333) R_3

R_4 = 80 kΩ

Filters

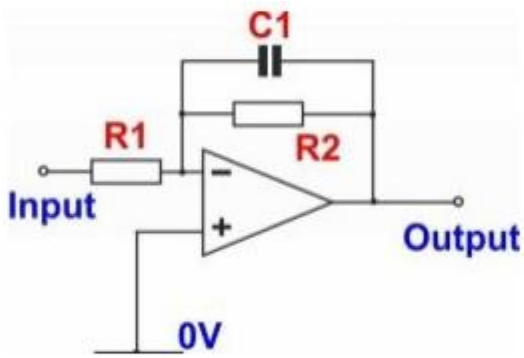
Q3: Explain how operational amplifiers could be used as low pass filter, emphasizing on the basic components' properties that facilitate this application.

Draw the low pass filter circuit, and derive the mathematical equation of the low pass filter.

Answer:

In the low pass filter circuitry, a capacitor is placed, in the feedback, across the resistor. As the frequency of input signal increases, the reactive impedance of the capacitor falls. This decreases the resultant impedance of the feedback loop, resulting in lower gain at higher frequencies. Conversely, the amplifier gain is still high at lower frequencies. That allows the amplifier to pass low frequencies while blocking higher ones.

Low pass filter circuit



$$Xc = \frac{1}{2\pi f c}$$

Where:

Xc is the capacitive reactance in ohms

π is 3.14

f is frequency in Hertz

C is the capacitance in Farads

Amplifier gain = Z_{out}/Z_{in}

$zout = \frac{\frac{R2}{2\pi f c}}{\frac{1}{2\pi f c}+R2}$, and Z_{in} = R1

Low pass filter gain = $\frac{R2}{R1}(\frac{1}{1+2\pi f c R2})$