ANALOG SYSTEMS : PROBLEM SET 9

Problem 1

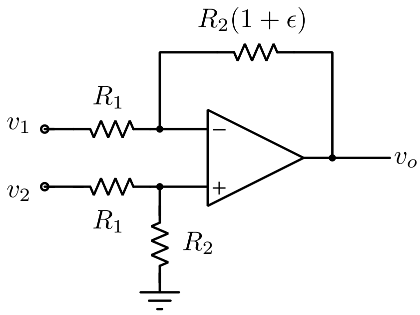

Figure 1: Circuit for Problem 1.

Fig. 1 shows a difference amplifier. In class, we analyzed the effect of finite CMRR of the opamp on the CMRR of the difference amplifier. In this problem, we will attempt to understand what happens when the opamp is ideal (CMRR = ∞), but when the resistors are mismatched.

Ideally, the feedback resistor is R_2. Assume that it is slightly off, so that it is $R_2(1+\epsilon)$, where $\epsilon \ll 1$. Defining $v_{cm} = (v_1 + v_2)/2$ and $v_{dm} = (v_1 - v_2)/2$, determine the common-mode and differential-mode gains, and the CMRR of the difference amplifier.

Problem 2

In the amplifier of Fig. 1, the opamp is dominant pole compensated, and has a gain-bandwidth product of 1 MHz. ϵ can be assumed to be zero. Determine the bandwidth of the difference amplifier.

Problem 3

A common requirement is to have a difference amplifier that is also capable of variable gain. In the circuit of Fig. 1, determine a way of achieving this.

The circuit of Fig. 2 shows and improvement. Determine the signs of the opamp, and v_o in terms of v_1 and v_2.

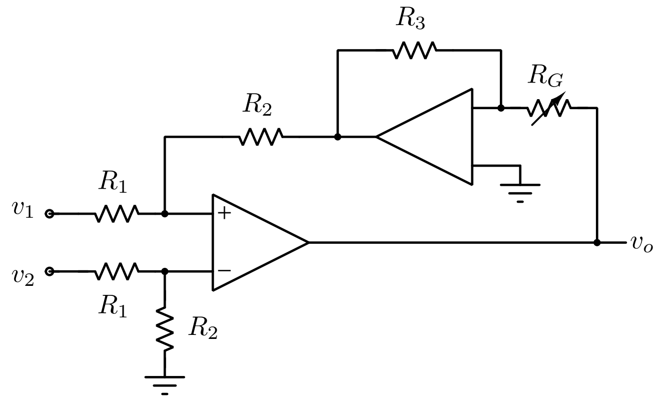

Figure 2: Circuit for Problem 3.

Problem 4

Determine the gain of the circuit of Fig. 3.

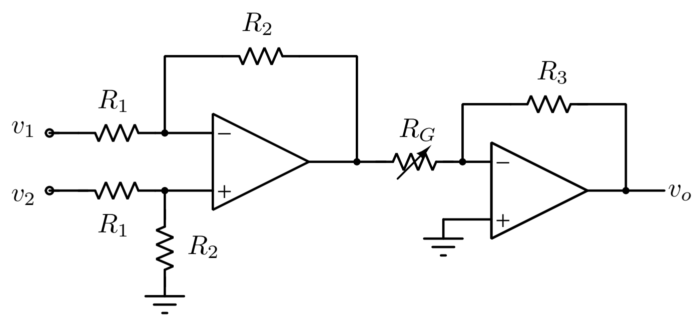

Figure 3: Circuit for Problem 4.

R_1, R_2 and R_3 are identical in the circuits of Fig. 2 and Fig. 3. How should R_G in Fig. 3 be chosen so as to achieve the same gain as the circuit of Fig. 2? Assuming the opamps are dominant pole compensated, and have a gain-bandwidth product of 1 MHz, determine the transfer functions of the amplifiers of Fig. 2 and Fig. 3.

Problem 5

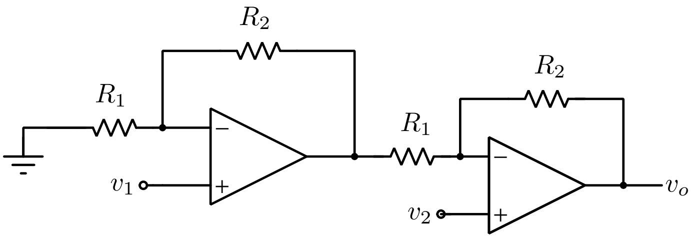

Figure 4: Circuit for Problem 5.

Determine v_o in terms of v_1 and v_2, assuming ideal opamps. Next, assume that the opamp's transfer functions are modeled as GB/s, where GB denotes the gain-bandwidth product. Determine the CMRR of this amplifier as a function of frequency. What do you observe?

Problem 6

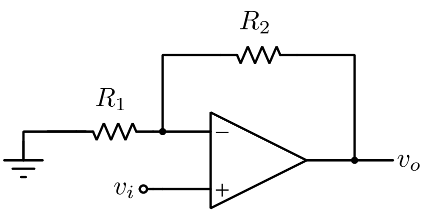

Figure 5: Circuit for Problem 6.

Fig. 5 shows an amplifier. The opamp has a gain-bandwidth product of GB. Determine the 3-dB bandwidth of the amplifier. N such stages are cascaded to result in a dc gain of $(1 + R_2/R_1)^N$. Determine the 3-dB bandwidth of the cascade in terms of the 3-dB bandwidth of a single stage.

Problem 7

Fig. 6 shows three networks consisting of arbitrary number of resistors, capacitors, inductors and ideal opamps (assumed to be enclosed in negative feedback loops). The input impedance and transfer function (as functions of frequency) of the top-most network are denoted by $Z_{in}(s)$ and $H(s)$ respectively. Determine the input impedance and transfer functions of the lower two networks. In the second network, *all* resistors are multiplied by m, *all* capacitors are reduced by m and *all* inductors are increased by a factor m.

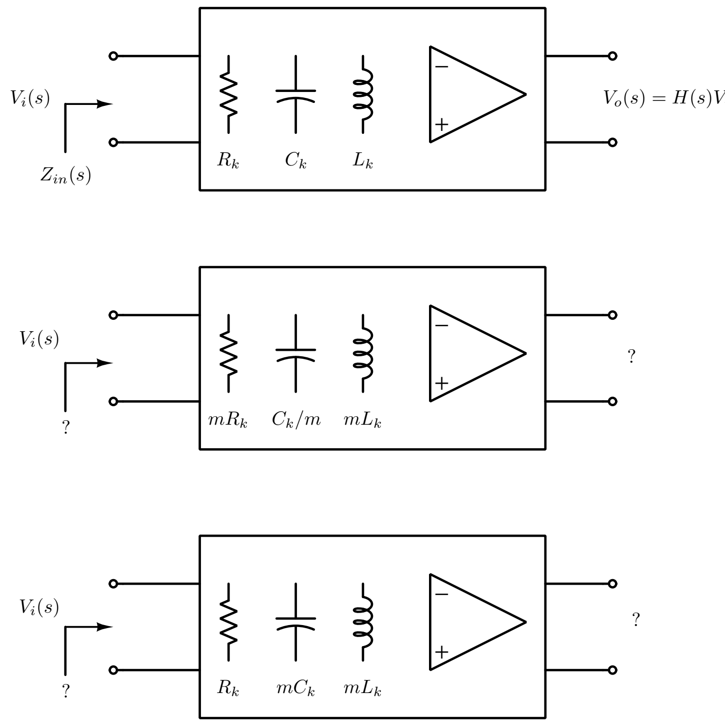

Figure 6: Circuit for Problem 7.