Cairo University
Faculty of Engineering
Elec. & Comm. Dept.

Electronics (3)
Third Year - First Term
Fall 2011

Sheet 2: Linear Op-Amp Circuit Applications

1. An almost ideal op-amp has an open-circuit output voltage Vo = 10V and a gain A=100dB.
   a) What is the input voltage V_{id}?
   b) How large gain must be to make $V_{id} \leq 1\mu V$?

2. Assuming ideal op-amp, find the gain and input resistance for the following circuits:

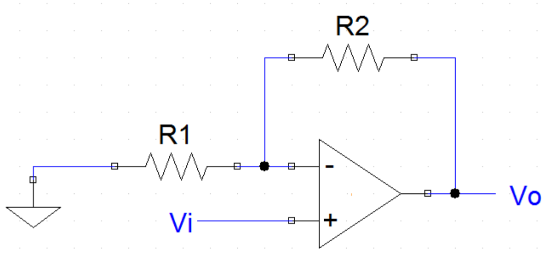

Fig. (P2-a)

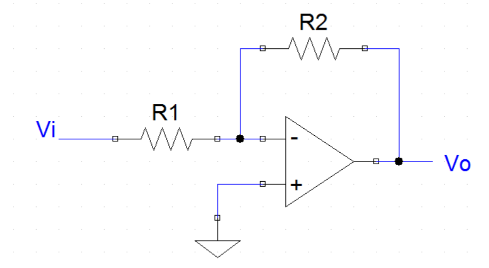

Fig.(P2-b)

3. Assuming ideal op-amp, write V_O as a function of V1 & V2 in the following figure. Can you suggest an application for this circuit?

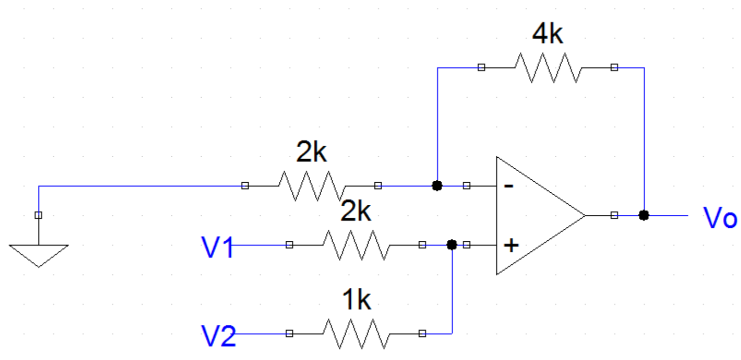

Fig. (P3)

4.
   a) Assuming ideal Op-amp, what are the gain, input resistance, and output resistance of the amplifier in Fig.(P4) if R_1= 180 Ω and R2 = 47 kΩ? Express the gain in dB.

   b) If the resistors have 10% tolerances, what are the worst-case values (highest and lowest) of gain that could occur? What are the resulting positive and negative tolerances on the voltage gain with respect to the ideal value?

c) Show the contradiction in satisfying both the gain and input resistance conditions for a typical inverting voltage amplifier and how this problem can be alleviated with a non-inverting configuration

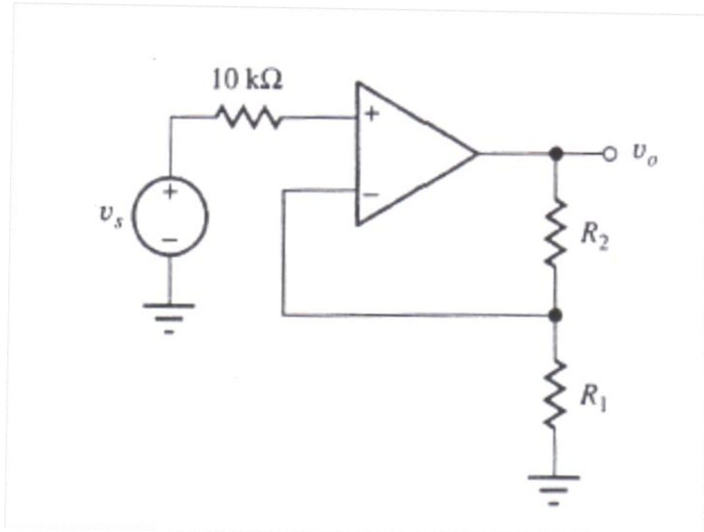

Fig. (P4)

5. For the following circuit:
   a) Get V_O in terms of V_{I1} & V_{I2}.
   b) Find the condition on the resistances to use it as a difference amplifier. Then calculate the common mode gain, differential input resistance and the CMRR. State the main disadvantage to use it as a difference amplifier.

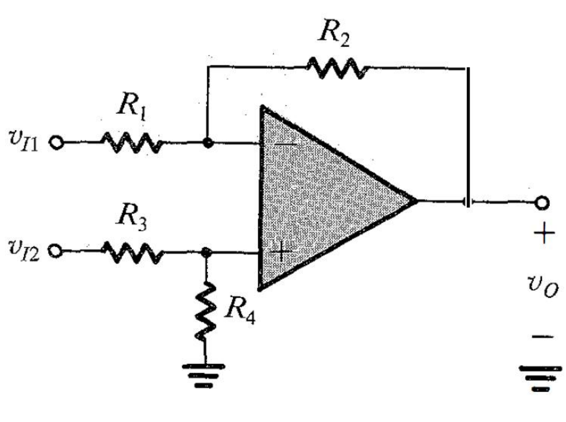

Fig. (P5)

6. What is the voltage gain of the instrumentation amplifier in Fig. (P6) if R_1= 20 kΩ , R_2=100 kΩ, R_3=10 kΩ and R_4= 10 kΩ. Write an expression for the output voltage if

$v_1 = 4 - 0.1\sin(4000\pi t)$ V and $v_2 = 4 + 0.1\sin(4000\pi t)$ V. Discuss its advantages over a regular difference amplifier.

7.

a) The input voltage of the integrator circuit in Fig. (P7) is a rectangular pulse with amplitude of 5 V and a width 1ms. Draw the waveform at the output of the integrator if the pulse starts at t=0, R=10 kΩ and C=0.1 μF. Assume $v_0 = 0$ for $t \leq 0$.

b) Repeat (a) if the capacitor is initially charged to 0.5 V, i.e. $v_0 = 0.5$ V for $t \leq 0$. Suggest a method to eliminate this initial voltage.

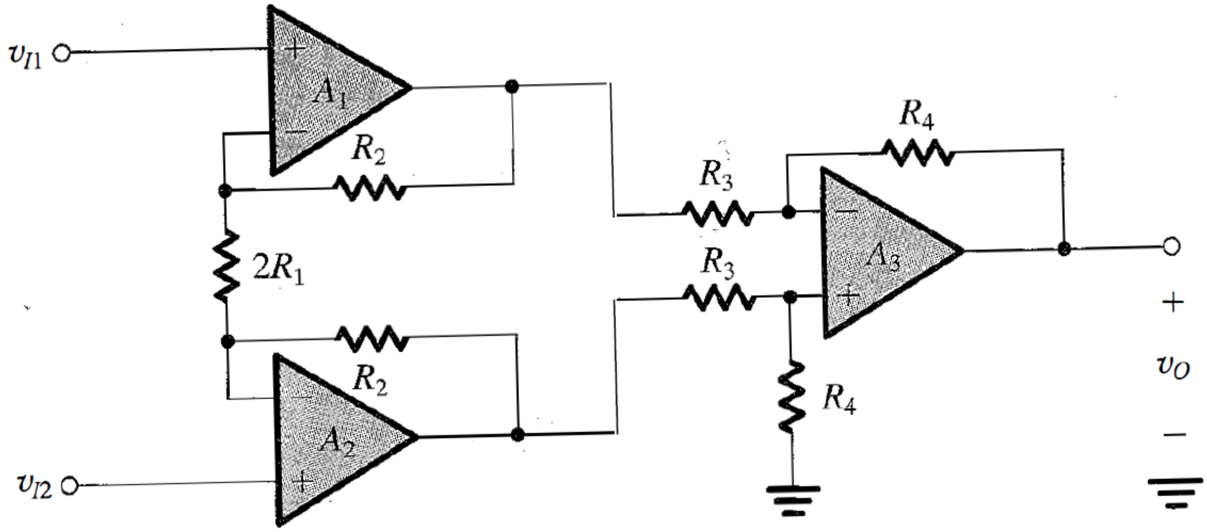

Fig. (P6)

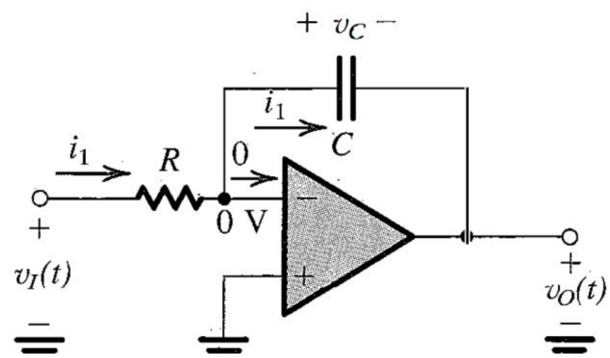

Fig. (P7)

8. Assuming ideal op-amp, find the relation between V_i and V_o for the following circuit. State its function.

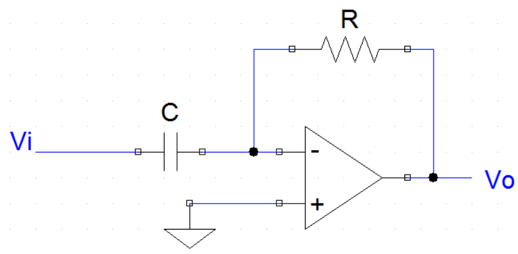

Fig. (P8)

9. Show, using ideal Op-Amps, how to realize a PID controller that has the input/output relation: $y = k_1 x + k_2 \int x\,dt + k_3 \frac{dx}{dt}$. Find the constants k_1, k_2 and k_3 in terms of the used resistors and/or capacitors.

<u>Op-Amps non-idealities:</u>

10. Find the gain and input resistance for the circuits in Fig. (P10) if the Op-amp has finite open loop gain (A) and input resistance (Rin)

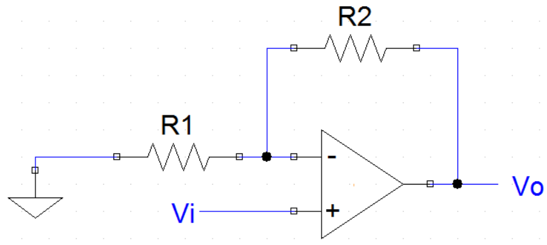

Fig. (P10-a)

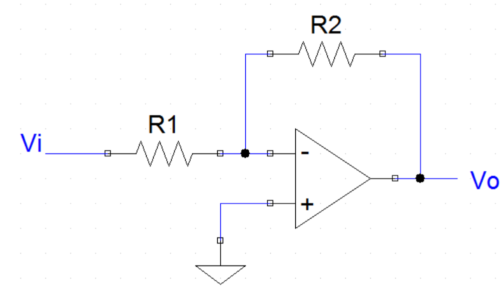

Fig. (P10-b)

11. Calculate the worst-case output voltage for the circuit in Fig. (P11) if V_{OS} = 1mV, I_{B1} = 100 nA, and I_{B2} = 95 nA. What would the ideal output voltage be? What is the total error in this circuit? Is there a better choice for the value of R1? If so, what is the value?

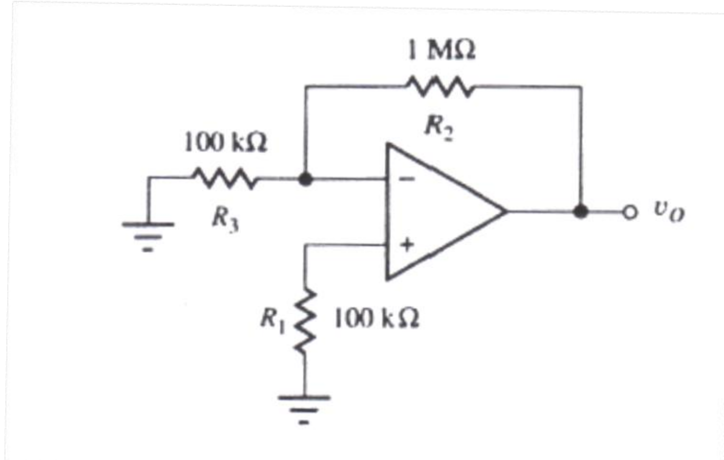

Fig. (P11)