COLLEGE OF ENGINEERING & TECHNOLOGY

Department: Electronics and Communications

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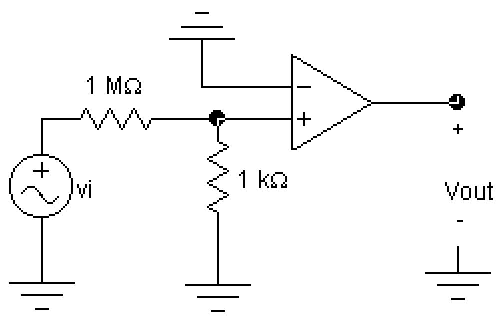
Course : Electronic Circuits II

Course Code: EC 432 **Sheet: 3**

1. What is the minimum number of terminals required by a single op amp? What is the minimum number of terminals required on an IC package containing four op amps (called a quad op amp)?

2. The circuit shown below uses op amp that is ideal except for having a finite gain A. Measurements indicate that v_O=3.5V when v_I =3.5V. What is the op amp gain?

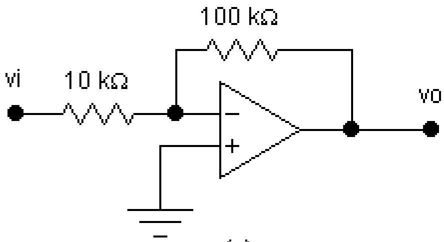


3. An inverting amplifier uses an ideal op amp with R_1=33kΩ and R_2=330kΩ. What is the closed-loop gain you would expect? A second resistor is connected at the input:
   - a- in series with the existing 33kΩ.
   - b- in parallel with the existing 33kΩ

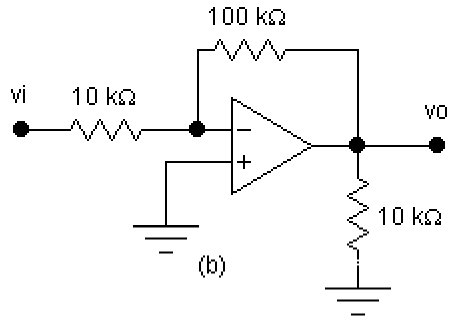
   What values of gain result?

4. Assuming ideal op amps, find the voltage gain v_O/v_I and input R_{in} in each of the circuit below:

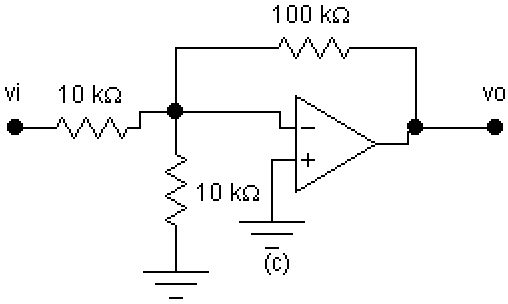
M


100 kΩ
vi
10 kΩ
vo

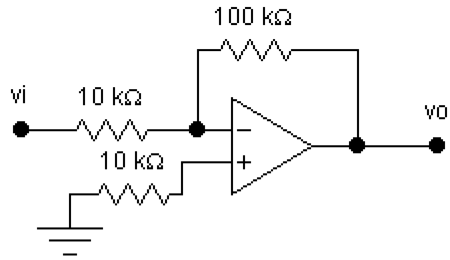
(a)


100 kΩ
vi
10 kΩ
vo
10 kΩ

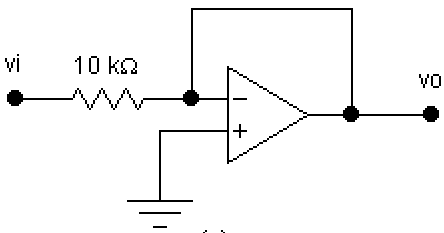
(b)


100 kΩ
vi
10 kΩ
vo
10 kΩ

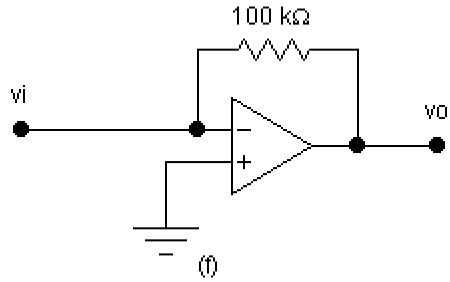
(c)


100 kΩ
vi
10 kΩ
vo
10 kΩ

(d)


vi
10 kΩ
vo

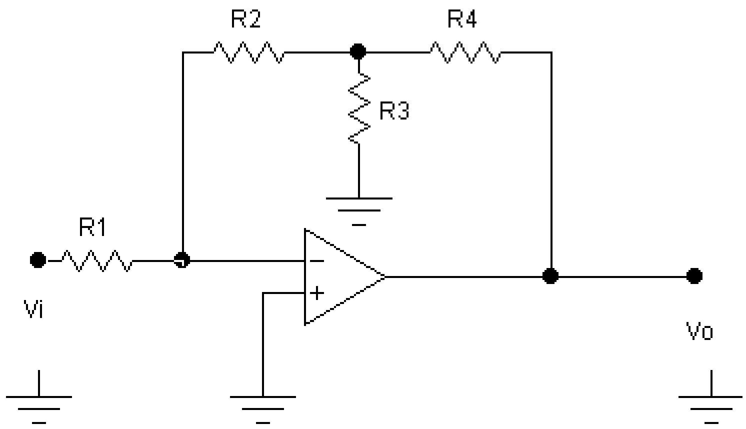
(e)


100 kΩ
vi
vo

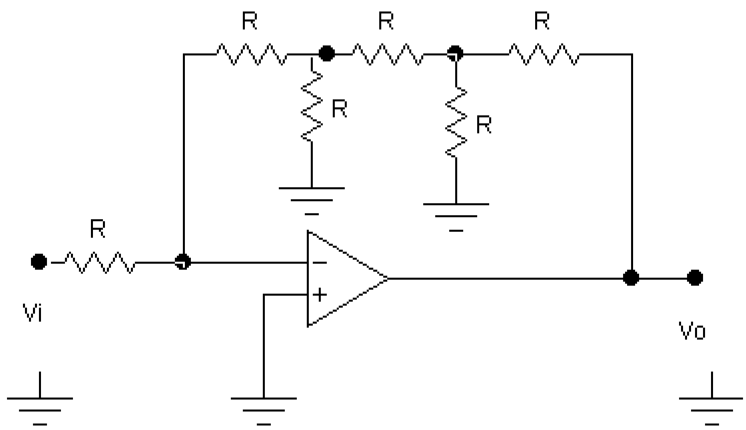
(f)

5. Consider The circuit shown below with $R_1=R_2=R_4=1M\Omega$, and assume the op amp to be ideal . Find values for R_3 to obtain the following gains:

a- -10 V/V
b- -100 V/V



6. For the circuit given in problem (5), What gain results if all resistors are equal?. An extension of this circuit is shown below, determine its gain.



7. A Miller integrator incorporates an ideal op amp, a resistor R of $100k\Omega$, and a capacitor C of $0.1\,\mu F$. A sine wave is applied to its input.
   a- At what frequency in Hz are the input and output signals are equal in magnitude?
   b- At that frequency, how does the phase of the output sine wave relate to that of the input?
   c- If the frequency is lowered by a factor of 10 from that found in (a), by what factor does the output voltage change, and in what direction (smaller or lager)?
   d- What is the phase relation between the input and output in situation (c)?
8. A Miller integrator whose input and output voltages are initially zero and whose time constant is 1ms is driven by a square wave signal whose amplitude is ± 1V and periodic time is 1ms. Sketch and label the output wave form that results during the first 1ms. Indicate what happens if the input levels are ± 2V, with the time constant the same and with the time constant raised to 2ms.

9. a- Use the superposition to show that the output of the circuit below is given by:

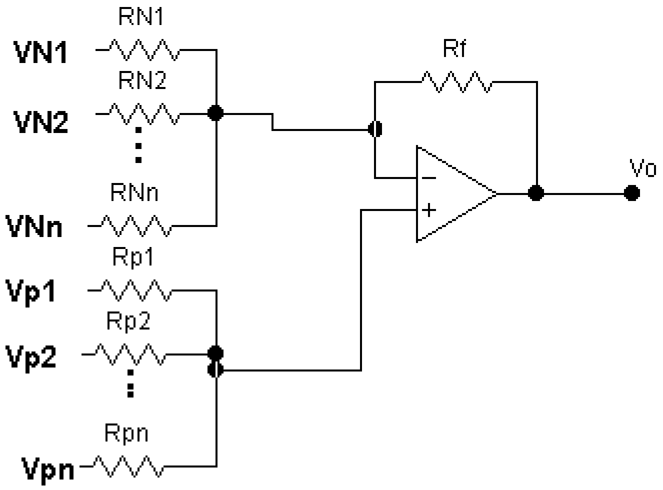
$$V_o = -R_f\left[\frac{v_{N1}}{R_{N1}} + \frac{v_{N2}}{R_{N2}} + ... + \frac{v_{Nn}}{R_{Nn}}\right] + \left(1 + \frac{R_f}{R_N}\right)R_p\left[\frac{v_{p1}}{R_{p1}} + \frac{v_{p2}}{R_{p2}} + ... + \frac{v_{pn}}{R_{pn}}\right]$$

where $R_p = R_{p1} // R_{p2} // R_{p3} // .... R_{pn}$, and

$R_N = R_{N1} // R_{N2} // R_{N3} // .... R_{Nn}$

b- Design a circuit to obtain:

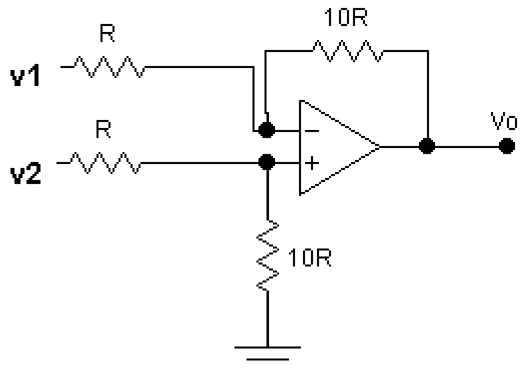
$$V_o = -2v_{N1} + v_{p1} + 2v_{p2}$$



10. For the circuit shown below, use the superposition to find V_o in terms of the input voltages v_1 and v_2. Assume an ideal op amp for:

$$v_1 = 10\sin(2\pi \times 60t) - 0.1\sin(2\pi \times 1000t), volts$$

$$v_2 = 10\sin(2\pi \times 60t) + 0.1\sin(2\pi \times 1000t), volts$$



11. It is required to connect a 10-V source with a source resistance of 100kΩ to a 1-k Ω load. Find the voltage that will appear across the load if:
    a- the source is connected directly to the load.
    b- An op-amp unity-gain buffer is inserted between the source and the load.

In each case, find the load current and the current supplied by the source. Where does the current come from in case (b)?

12. Consider the instrumentation amplifier discussed in the lecture with a common-mode input voltage of +5V (dc) and a differential input signal of 10-mV peak sine wave. Let R_1 =1k Ω, R_2=0.5M Ω, R_3=R_4=10k Ω . Find the voltage at every node of the circuit.

13. The data in the following table apply to internally compensated op amps. Fill in the blank entries.

A_o	f_b (Hz)	f_t (Hz)
10^6	1	
10^6		10^6
	10^6	10^8
	10^{-1}	10^6
$2\text{x}10^6$	10	

14. A measurement of the open-loop gain of an internally compensated op amp at very low frequencies shows it to be $4.2\text{x}10^4$V/V; at 100kHz shows it is 76V/V. Estimate values for A_o, f_b, and f_t.
15. An inverting amplifier with nominal gain of –20V/V employs an op amp having a dc gain of 10^4 and a unity-gain frequency of 10^6. What is the 3-dB frequency f_{3dB} of the closed-loop amplifier? What is its gain at 0.1 f_{3dB} and 10 f_{3dB}?
16. Consider the use of an op amp with a unity-gain frequency f_t in the realization of:
    - a- an inverting amplifier with a dc gain of magnitude K.
    - b- a noninverting amplifier with a dc gain of K.

    In each case find the 3-dB frequency and the gain bandwidth product (GBP=$|G| \times f_{3dB}$). Comment on the results.
17. **a-** Show that the transfer function of a Miller integrator realized using an internally compensated op amp with a unity-gain frequency ω_t is given approximately by:

$$\frac{V_0}{V_i} \cong -\frac{1}{j\omega CR}\frac{1}{1+j(\omega/\omega_t)}$$

where it has been assumed that ω_t is much higher than the integrator frequency ω_o (ω_o=1/CR).

b- What is the "excess phase" that the integrator has due to the op amp ω_t at ω_t/100? Is the excess phase of the lag or lead type?

18. A differential amplifier for which the input signal are:

$$v_1 = 10.00\sin(2\pi\,60t) + 0.01\sin(2\pi\,1000t)$$

and

$$v_2 = 10.00\sin(2\pi\,60t) - 0.01\sin(2\pi\,1000t)$$

has an output

$$v_o = 0.1\sin(2\pi\,60t) + 5\sin(2\pi\,1000t)$$

For this situation, calculate the common-mode gain, the difference-mode (or differential) gain, and the CMRR both as a ratio and in dBs.

19. In somewhat more complex situation than prevail in problem 18, the major (common) interfering signals may be not totally balanced at the two inputs. Such is the case in which :

$$v_1 = 10.00\sin(2\pi\,60t) + 0.04\sin(2\pi\,1000t)$$

$$v_2 = 10.01\sin(2\pi\,60t) - 0.04\sin(2\pi\,1000t)$$

and

$$v_o = \sin(2\pi\,60t) + 4\sin(2\pi\,1000t)$$

Calculate the difference-ode gain, the common-mode gain and the CMRR.