Department of Avionics,

Indian Institute of Space Science & Technology, Trivandrum

Instrumentation and Measurement, Instructors: Anoop C. S.

Tutorial No. 3

Q. 1. Compute the output of the circuit in Fig. 1, if its input terminals are tied to 10 V. Assume opamp has a CMRR of 80 dB and ideal resistors. **1 mV**

Q. 2. Compute the CMRR of the differential amplifier circuit shown in Fig. 1. Assume resistors R have a tolerance of 1 % and ideal opamp **33.98 dB ≈ 34 dB**

Q. 3. Find the output voltage of the following circuit in Fig. 2. **Ans: 4 V**

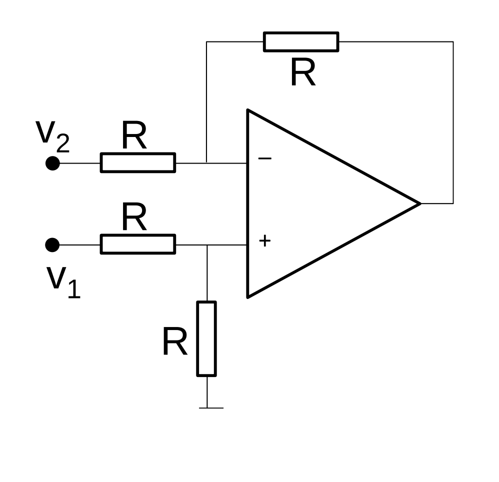


Fig. 1

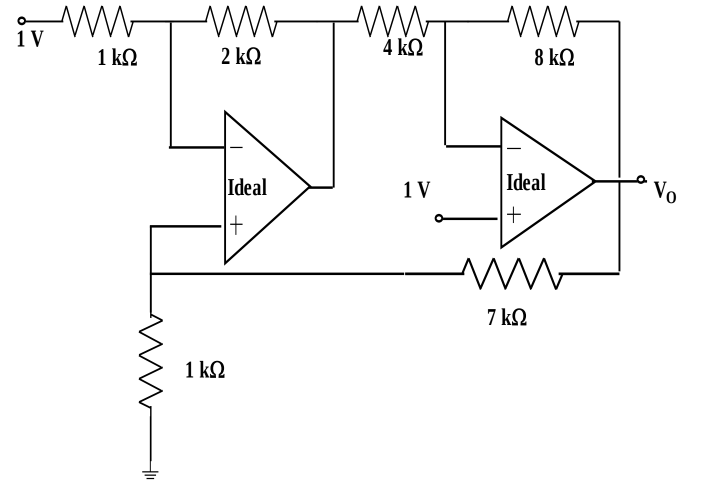


Fig. 2

Q. 3. Find the output voltage of the circuit (Fig. 3) at switch positions 1, 2, and 3.

Ans: 10 V, 20 V, 30 V

Q. 4. Find V_O, I_O and output power, P_O of the circuit in Fig. 4. **Ans: 12 V, 2.1 mA, 25.2 mW**

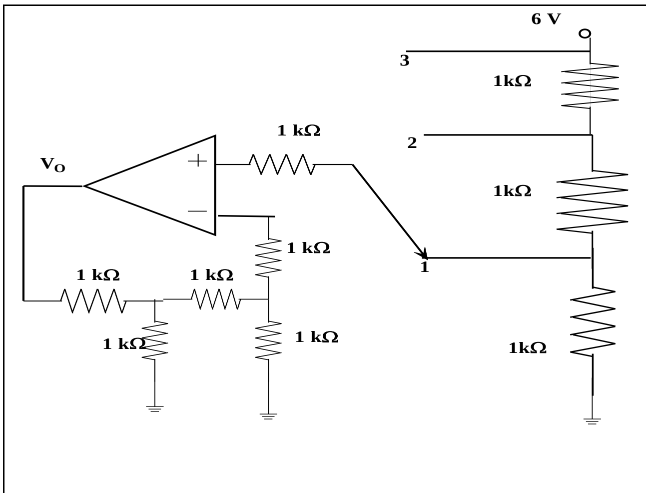


Fig. 3

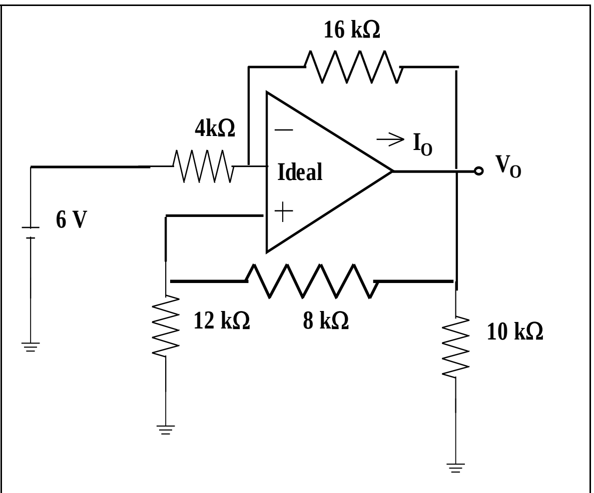
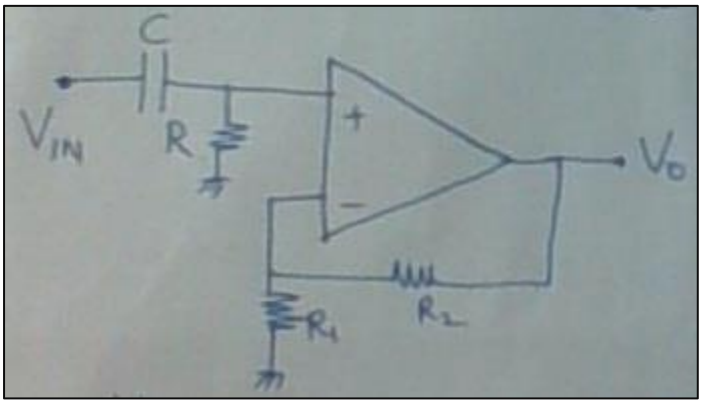


Fig. 4

Q. 5. A first order active non-inverting high pass filter with a pass band gain of two and a cut-off frequency of 1 kHz needs to be designed. A 10 nF capacitor is given to you. Design the resistors should be used. Also, plot the expected frequency response of the filter.

Ans: Resistance (R) = 15.92 kΩ, R1 = R2 = high value (may, around ten of kΩs) to reduce current consumption. High pass type frequency response can be plotted easily.



Q. 6. Consider a non-inverting amplifier (gain = 10) realized using a 1 kΩ resistor and a 10 kΩ resistor. The opamp used has an input offset voltage (V_{OS}) of 10 mV and input bias current (I_B) of 300 nA and input offset current (I_{OS}) of 50 nA.
(a) Find the maximum error in output voltage (note that this error voltage at output is otherwise known as output offset voltage) due to I_B and V_{OS}.
(b) Determine the value of compensation resistor that can reduce the effect due to I_B. Find the maximum output offset voltage when such a resistor is included in the circuit.

Q. 7. A square wave of 500 mV peak-to-peak amplitude needs to be amplified to 3 V peak-to-peak amplitude. It is given that the time taken for the output to transit from its minimum value to its maximum value should be less than 4 μs. Can 741 be used as the opamp for the above application.

Q. 8. Find the output voltage of the circuits given below

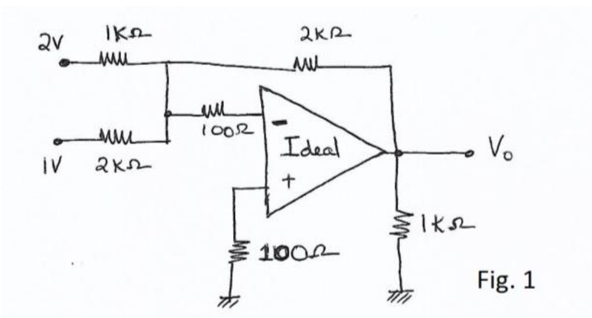
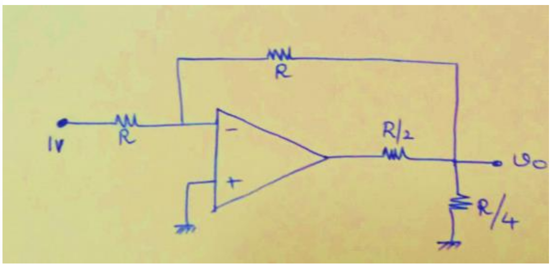
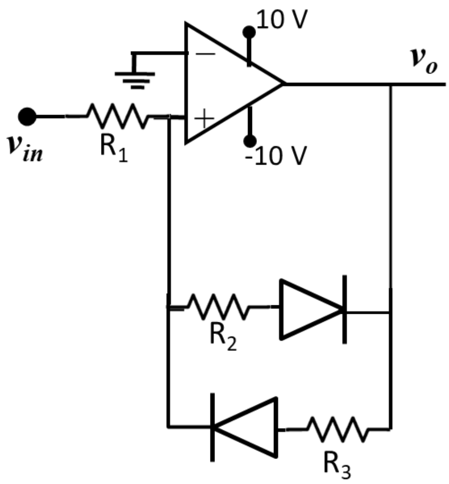


Fig. 1



Q. 9. A (bipolar) square wave of amplitude 0.3 V has to be amplified to amplitude of 3 V. The output should rise from its low-level to its high-level within 5 μs. Comment on the slew-rate specification for the opamp, which can be used for this circuit.

Q. 10. Identify the below circuit and describe its working using a sine wave input, v_{in}



Q. 11. Derive the transfer function of the circuit given in Fig. 5. Mention its possible use.

Ans: All pass filter. Transfer function: $\dfrac{-1+j\omega CR}{1+j\omega CR}$

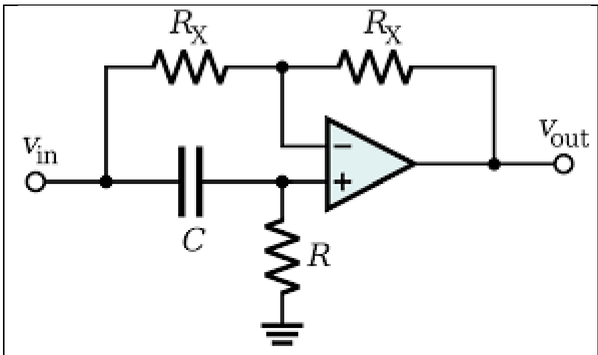


Fig. 5

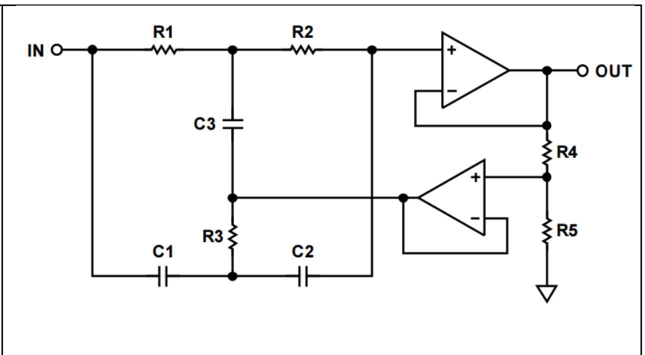


Fig. 6

Q. 12. Derive the transfer function of the circuit given in Fig. 6. Assume R1 = R2 = 2*R3 = R, C1 = C2 = C3/2 = C. Comment on its function and an advantage over a similar passive circuit, which performs the same function.

Ans: Active Twin-T Notch filter.

Transfer function: $\dfrac{1+(j\omega CR)^2}{1+(j\omega CR)^2+j4(1-\beta)\omega CR}, where\ \beta=\dfrac{R_5}{R_4+R_5}$**, In this active filter circuit, Q = 1/(4 – 4 β). Hence, Q can be varied by changing β. This is an advantage over the passive Twin-T Notch filter, where Q is fixed at 0.25**

Q. 13. Find out the transfer relation of the circuit shown in Fig. 7. Identify its function.

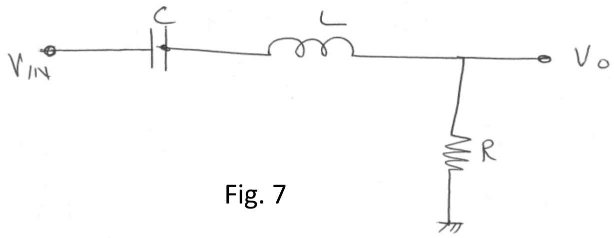


Fig. 7

Ans: $$\frac{V_O}{V_{IN}}(j\omega)=\frac{j\omega R/L}{(j\omega)^2+j\omega R/L+1/(LC)}$$

Q. 14. Find out the transfer relation of the circuit shown in Figure below. Show that this circuit performs similar function as the one in Fig. 1. Compare the characteristics of the circuits in Fig. 7 and Fig. 8.

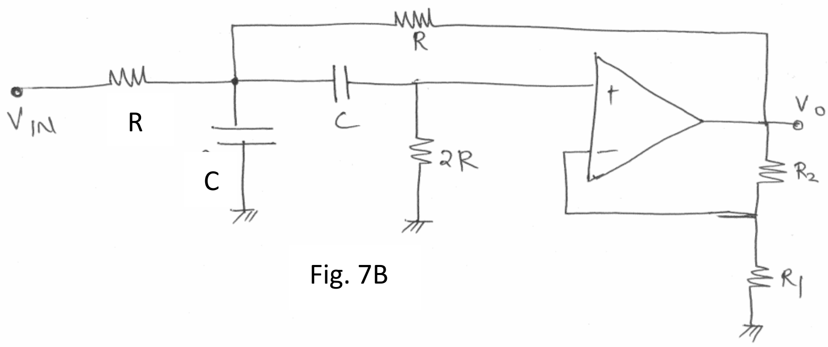


Fig. 7B

Circuit can be used to obtain any value of damping factor, without using inductors.

Its transfer relation is $$\frac{V_o}{V_i}(j\omega)=\frac{j\omega CR}{(j\omega CR)^2\beta+j\omega CR(3\beta-1)+\beta}$$

Both the circuits in Fig. 7 and Fig. 8 performs band-pass filtering.

Q. 15. Determine the transfer relation of the circuit shown in Fig. 7C. Identify its function.

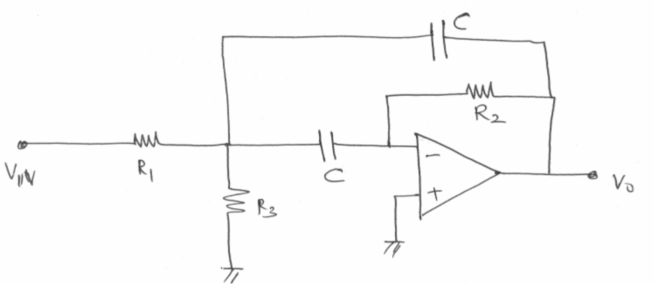


Fig. 7C

Band-pass filter. Its transfer relation is $$\frac{V_o}{V_i}(j\omega)=\frac{-j\omega CR_2R_3}{(j\omega C)^2R_1R_2R_3+j2\omega CR_1R_3+R_1+R_3}$$

Q. 16. Determine the function of the circuit of the circuit in Fig. 7D. Find out its undamped natural frequency and damping factor.

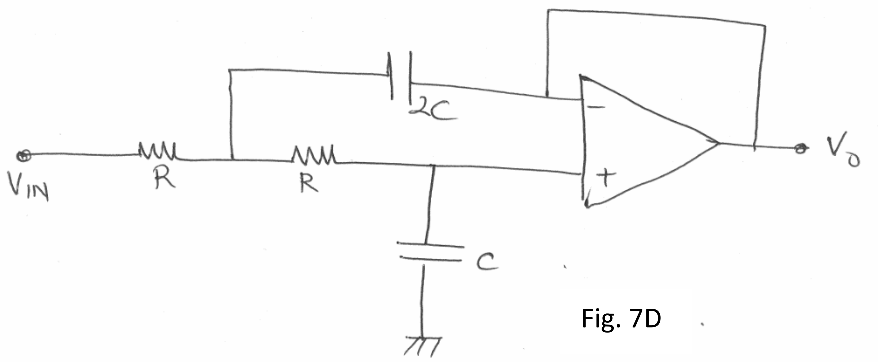


Fig. 7D

Low-pass filtering, Damping factor = 0.707, Natural frequency = 0.707/(RC)

Q. 17. Determine the function of the circuit of the circuit in Fig. 7E. Find out its undamped natural frequency and damping factor.

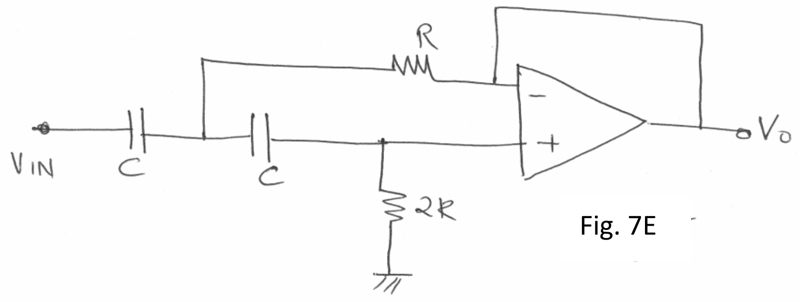


Fig. 7E

High-pass filtering, Damping factor = 0.707, Natural frequency = 0.707/(RC)

Q. 18. Determine the function of the circuit of the circuit in Fig. 7F. Find out its undamped natural frequency and damping factor. What is the role of “2R” resistor?

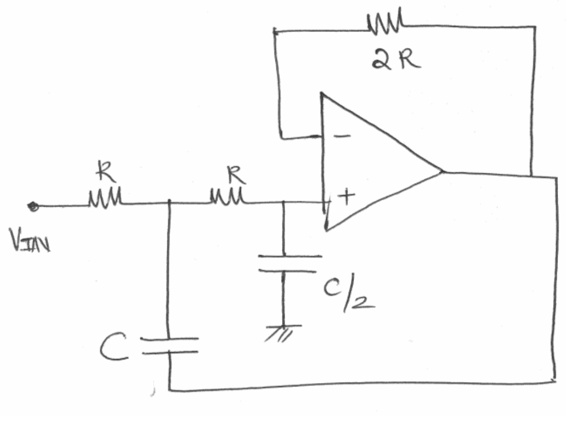


Fig. 7F

Low-pass filtering, Damping factor = 0.707, Natural frequency = 1.414/(RC).

2R – bias current compensation.

Q. 19. Identify the circuit in Figure below. Draw the input and output waveforms and mention its advantage over a passive circuit which performs an equivalent function.

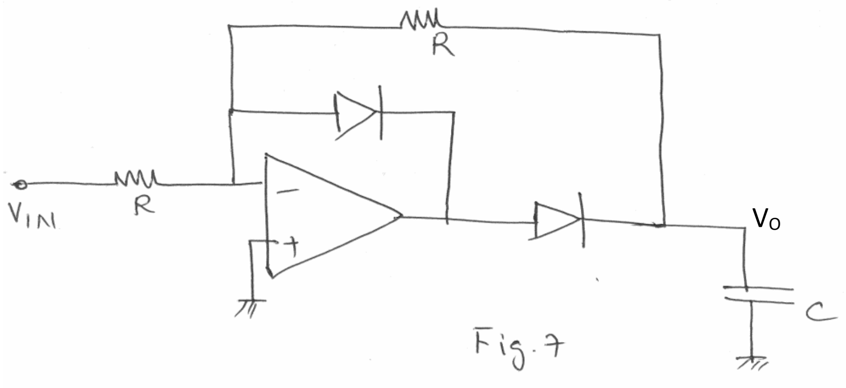


Fig. 7

Q. 20. The input V_{IN} to the circuit in Fig. 8 is a sine wave with a frequency of 100 Hz. Design the circuit such that its output V_O will indicate the RMS value of V_{IN}.

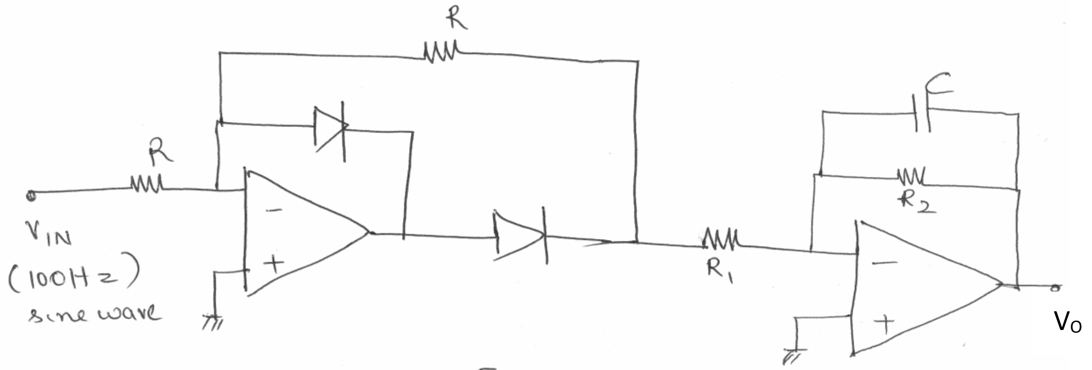


Fig. 8.