Chapter 5
Operational Amplifier

One mark questions (knowledge)

1. What is a differential amplifier?
2. What is an op-amp?
3. Draw the pin configuration of IC-741.
4. Write any one ideal characteristics of op-amp.
5. Define input offset voltage.
6. Define CMRR of an op-amp.
7. Mention the CMRR value of an ideal op-amp.
8. Define slew rate of an op-amp.
9. Mention the unit of slew rate.
10. Mention any one linear application of op-amp
11. Mention any one non-linear application of op-amp.
12. What is the phase difference between the input and output of an inverting op amp?
13. What is the phase difference between the input and output of a non-inverting op amp?
14. What is the advantage of using op-amp as a buffer?
15. Write an expression for output voltage of three input inverting op-amp adder when V_1, V_2 and V_3 are the inputs given to it. Consider that all the resistors used are identical.
16. Write an expression for output voltage of three input op-amp adder when V_1, V_2 and V_3 are the inputs given to it, considering the resistors used are of different values.
17. Write an expression for output voltage of an op-amp subtractor when V_1 is given to inverting terminal and V_2 is given to non-inverting terminal. Consider that all the resistors used are identical.
18. Write the expression for output voltage of op-amp subtractor when $V_1$is given to inverting terminal and V_2 is given to non-inverting terminal, considering the resistors used are of different values.
19. What is an op-amp differentiator?
20. Write an expression for output voltage of an op-amp differentiator.
21. What is an op-amp integrator?
22. Write the expression for output voltage of an op-amp integrator.
23. What is an op-amp logarithmic amplifier?
24. Write an expression for output voltage of an op-amp logarithmic amplifier.
25. Mention any one application of an op-amp logarithmic amplifier.
26. What is an op-amp anti-logarithmic amplifier?
27. Write the expression for output voltage of an op-amp anti-logarithmic amplifier.
28. Write any one application of an op-amp anti-logarithmic amplifier.
29. What is an op-amp active filter?
30. Write an expression for cut off frequency of an op-amp first order low pass active filter.
31. Write the expression for cut-off frequency of an op-amp first order high pass active filter.
32. What is a digital to analog converter?
33. What is an analog to digital converter?
34. Name any one open loop application of an op-amp.
35. What is an op-amp comparator?
36. What is a Schmitt Trigger?

37.Why Schmitt Trigger is known as square wave generator?
38.What type of feedback is used in Schmitt Trigger?
39.Name any one application of Schmitt Trigger.

One mark questions (understanding)

1. Why is input current drawn by an ideal op-amp zero?
2. When does a comparator produce zero output?

One mark questions (skill)

1. Draw the circuit symbol of an op-amp.
2. Draw the circuit diagram of an op-amp subtractor.
3. Draw the circuit diagram of an op-amp differentiator.
4. Sketch the output of an op-amp differentiator if the input is a square wave.
5. Sketch the output of an op-amp differentiator if the input is a sine wave.
6. Draw the circuit diagram of an op-amp integrator.
7. Write the expression for output voltage of an op-amp integrator.
8. Sketch the output of an op-amp integrator if the input is a sine wave.
9. Sketch the output of an op-amp integrator if the input is a square wave.
10. Draw the circuit diagram of an op-amp logarithmic amplifier.
11. Draw the circuit diagram of an op-amp anti-logarithmic amplifier.
12. Draw the circuit diagram of an op-amp first order low pass active filter.
13. Draw the frequency response curve of an op-amp low pass active filter.
14. Draw the circuit diagram of an op-amp high pass active filter.
15. Draw the frequency response curve for an op-amp first order high pass active filter.

Two mark questions (knowledge)

1. Name the different modes of a differential amplifier.
2. Mention the characteristics of an ideal op-amp.
3. Expand CMRR? Give its value for ideal op-amp.
4. Define CMRR. What is its importance?
5. With a circuit diagram briefly explain virtual ground concept of an op-amp.
6. What is an op amp buffer? Draw its circuit diagram.
7. Mention the types of digital to analog converters.
8. Mention any two applications of op amp comparator?
9. Draw the circuit diagram of an op-amp Schmitt trigger.

Two mark questions (understanding)

1. Why is an op-amp so called?
2. Distinguish between inverting and non-inverting operational amplifier.

Two mark questions (skill)

1. Draw the block diagram of an op-amp.
2. Draw the circuit diagram of an op-amp logarithmic amplifier and write the expression for its output voltage.
3. Draw the circuit diagram of an op-amp anti-logarithmic amplifier and write the expression for its output voltage.
4. Draw the circuit diagram of a four bit R-2R ladder network DAC.
5. Draw the circuit diagram of four bit binary weighted resistor DAC.

Three mark questions (knowledge)

1. Mention the characteristics of an ideal op-amp.
2. With a circuit diagram derive an expression for the output of an op-amp logarithmic amplifier.
3. With a circuit diagram derive an expression for the output of an op-amp anti-logarithmic amplifier.
4. Draw the circuit diagram, frequency response and expression for cut-off frequency for an op-amp first order RC low pass active filter.
5. Draw the circuit diagram, frequency response and expression for cut-off frequency for an op-amp first order RC high pass active filter.

Three mark questions (understanding)

1. Mention the characteristics of an ideal op-amp.
2. Draw the circuit diagram of an op amp inverting amplifier and derive an expression for its voltage gain.
3. Draw the circuit diagram of an op-amp non-inverting amplifier and derive an expression for its voltage gain.
4. Draw the circuit diagram of a three input inverting op-amp summing amplifier and derive an expression for its output voltage.
5. Draw the circuit diagram of an op-amp subtractor and derive an expression for its output voltage.
6. Draw the circuit diagram of an op-amp differentiator and derive an expression for its output voltage.
7. Draw the circuit diagram of an op-amp integrator and derive an expression for its output voltage.
8. With a circuit diagram derive an expression for the output of an op-amp logarithmic amplifier.
9. With a circuit diagram derive an expression for the output of an op-amp anti-logarithmic amplifier.
10. Draw the block diagram of the counting type analog to digital converter.
11. Draw the circuit diagram, frequency response and expression for cut-off frequency for an op-amp first order RC low pass active filter.
12. Draw the circuit diagram, frequency response and expression for cut-off frequency for an op-amp first order RC high pass active filter.

Three mark questions (skill)

1. Mention the characteristics of an ideal op-amp.
2. Draw the circuit diagram of an op amp inverting amplifier and derive an expression for its voltage gain.
3. Draw the circuit diagram of an op-amp non-inverting amplifier and derive an expression for its voltage gain.

4. Draw the circuit diagram of a three input inverting op-amp summing amplifier and derive an expression for its output voltage.
5. Draw the circuit diagram of an op-amp subtractor and derive an expression for its output voltage.
6. Draw the circuit diagram of an op-amp differentiator and derive an expression for its output voltage.
7. Draw the circuit diagram of an op-amp integrator and derive an expression for its output voltage.
8. With a circuit diagram derive an expression for the output of an op-amp logarithmic amplifier.
9. With a circuit diagram derive an expression for the output of an op-amp anti-logarithmic amplifier.
10. Draw the block diagram of the counting type analog to digital converter.
11. Draw the circuit diagram, frequency response and expression for cut-off frequency for an op-amp first order RC low pass active filter.
12. Draw the circuit diagram, frequency response and expression for cut-off frequency for an op-amp first order RC high pass active filter.

Five mark questions (Understanding)

1. Write the block diagram of an op-amp and explain each block in brief.
2. What are active filters? Give its classification. Draw the circuit diagram, frequency response and expression for cut-off frequency for an op-amp first order RC high pass filter.
3. What is an op amp summing amplifier? Draw the circuit diagram of a three input inverting op-amp adder and derive an expression for its output voltage.
4. What is an op amp subtractor? Draw the circuit diagram of an op-amp subtractor and derive an expression for its output voltage.
5. What is an op amp differentiator? Draw the circuit diagram of an op-amp differentiator and derive an expression for its output voltage.
6. What is an op amp integrator? Draw the circuit diagram of an op-amp integrator and derive an expression for its output voltage.
7. What is an op amp logarithmic amplifier? With a circuit diagram derive an expression for the output of an op-amp logarithmic amplifier.
8. What is an op amp anti-logarithmic amplifier? With a circuit diagram derive an expression for the output of an op-amp anti-logarithmic amplifier.

Problems:

1. If common mode gain and differential mode gain for a differential amplifier are 0.1 and 500 respectively, find CMRR in dB.

   (Ans: 74)
2. In an inverting amplifier, the input voltage is 0.5V and the output voltage is 2V. If the input resistance of the amplifier is 1.2 kΩ. Calculate the feedback resistance.

   (Ans:4.8kΩ)
3. In an inverting amplifier, the input voltage is 3V and the output voltage is 6V. If the feedback resistance of the amplifier is 10 kΩ. Calculate the input resistance.

   (Ans: 5 kΩ)
4. Calculate the output voltage of an inverting amplifier using an input resistance of 2.2 kΩ and feedback resistance of 6.8 kΩ when the input voltage is 0.2V.

   (Ans:0.62V)

5. Calculate the input voltage of an inverting amplifier using an input resistance of 100 Ω and feedback resistance of 120 Ω when the output voltage is 6V.

(Ans: 5V)

6. In a non-inverting amplifier, the input voltage is 0.5V and the output voltage is 2V. If the input resistance of the amplifier is1.2 kΩ. Calculate the feedback resistance.

(Ans: 3.6kΩ)

7. In a non-inverting amplifier, the input voltage is 2V and the output voltage is 6V. If the feedback resistance of the amplifier is 10 kΩ, calculate the input resistance.

(Ans: 5 kΩ)

8. Calculate the output voltage of a non-inverting amplifier using an input resistance of 120 Ω and feedback resistance of 180 Ω when the input voltage is 0.5V.

(Ans: 1.25V)

9. Calculate the input voltage of a non-inverting amplifier using an input resistance of 1.2 kΩ and feedback resistance of 1.8 kΩ when the output voltage is 6V.

(Ans: 2.4V)

10. Calculate the gain of a non-inverting amplifier, if R_f =1.8 kΩ and R_i = 1.2 kΩ.

(Ans: 2.5)

11. Calculate the gain of an inverting amplifier, if R_f =18 kΩ and R_i = 12 kΩ.

(Ans: -1.5)

12. The input signals to an adder circuit are 3mV, 6mV and 18mV through resistors of 120 Ω, 150 Ω and 180 Ω respectively. Find the value of feedback resistor to get an output of 50 mV.

(Ans: 303.03 Ω)

13. The input signals to an adder circuit are 6 mV, -3 mV and 9 mV through resistors of 1.2 kΩ, 1.5 kΩ and 1.8 kΩ respectively. Find the output voltage if the feedback resistance is 10 kΩ.

(Ans: 80mV)

14. Design an op-amp adder, if the output voltage $V_o = -(0.1V_1 + 0.4V_2 + 0.02V_3)$. Assume R_f = 22 kΩ.

(Ans: 220 kΩ, 55 kΩ, 1.1MΩ)

15. Determine the output voltage of op-amp subtractor when 4V input is given to inverting terminal and 2V input is given to non-inverting terminal. Consider all the resistors used are of same value.

(Ans: -2V)

16. Determine the output voltage of op-amp subtractor when 5V input is given to inverting terminal and 8V input is given to non-inverting terminal. Consider all the resistors used are of same value.

(Ans: 3V)

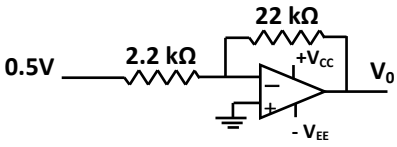
17. Determine the output voltage of 3 input op-amp adder when 0.5V, -2V and 5V are the inputs given to it. Consider all the resistors used are of same value.

(Ans: 3.5V)

18. Determine the output voltage of 3 input op-amp adder when 1.5V, 4V and 2V are the inputs given to it. Consider all the resistors used are of same value.

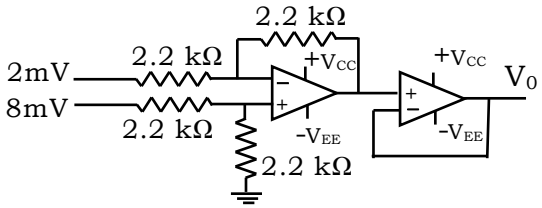
(Ans: 7.5V)

19. Calculate the output voltage for the circuit shown below.



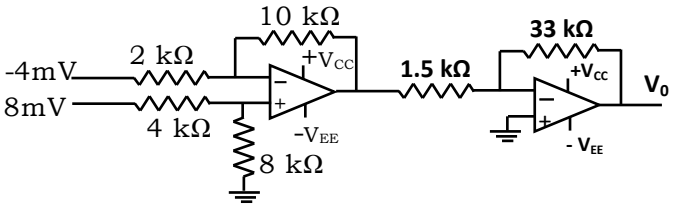
(Ans: - 5V)

20. Calculate the output voltage for the circuit shown below.



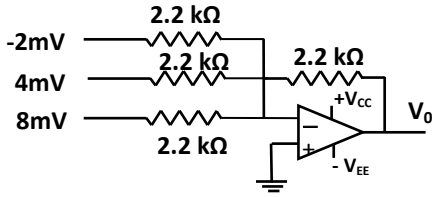
(Ans: + 6mV)

21. Calculate the output voltage for the circuit shown below.



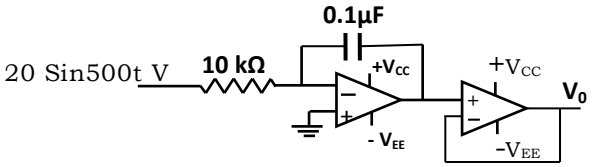
(Ans: -1.144V)

22. Calculate the output voltage for the circuit shown below.



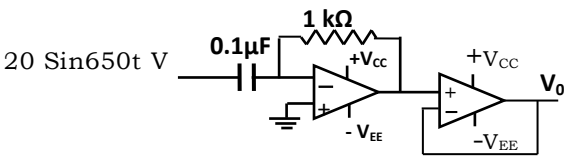
(Ans: -10mV)

23. Calculate the output voltage for the circuit shown below.



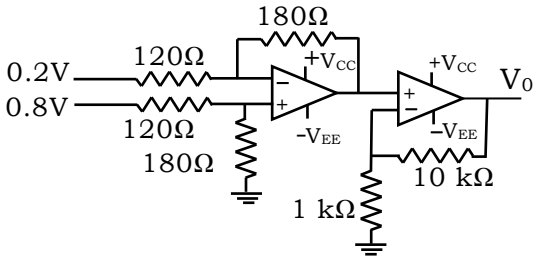
(Ans: 4cos500t V)

24. Calculate the output voltage for the circuit shown below.



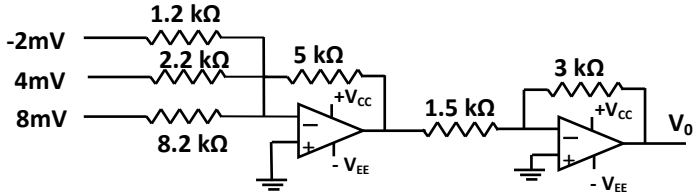
(Ans: -1.3Cos650t V)

25. Calculate the output voltage for the circuit shown below.



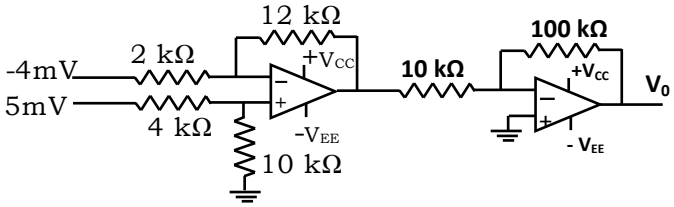
(Ans: 5.4V)

26. Calculate the output voltage for the circuit shown below.



Ans: 11.27mV)

27. Calculate the output voltage for the circuit shown below.



(Ans: -0.49V)

28. Calculate the cut-off frequency of a first-order low-pass filter for R = 1.2kΩ and C = 0.047µF.
(Ans: 2823.33 Hz)

29. Calculate the resistance of resistor of a first-order low-pass filter for f = 1.5kΩ and C = 0.022µF.
(Ans: 4825.32 Ω)

30. Calculate the capacitance of capacitor of a first-order low-pass filter for f = 1.59kΩ and R = 10kΩ.
(Ans: 10.01nF)

31. Calculate the cut-off frequency of a first-order high-pass filter for R = 1.2kΩ and C = 0.01µF.
(Ans: 13.26 kHz)

32. Calculate the resistance of resistor of a first-order high-pass filter for f = 10kΩ and C = 0.022µF.
(Ans: 723.79 Ω)

33. Calculate the capacitance of capacitor of a first-order high-pass filter for f = 15.9kΩ and R = 10kΩ.
(Ans: 1nF)