UNIT-II CHARACTERISTICS OF OPAMP

1. What is an opamp? List its functions.

The op-amp is a multi terminal device, which internally is quite complex. It is a direct coupled high gain amplifier consisting of one or more differential amplifiers, followed by a level translator and an output stage.

Function: Op-amp amplifies the difference between two input signals and can perform

2. List the ideal characteristics of an op-amp.

The ideal characteristics of an op-amp are as follows:

- Open loop voltage gain, $A_{OL} = \infty$
- Input impedance, $R_i = \infty$
- Output impedance, $R_O = 0$
- Bandwidth, $BW = \infty$
- Zero offset voltage, i.e. $V_O = 0$ when $V_1 = V_2 = 0$;

3. List the essential terminals of an op-amp.

Op-amp has five basic terminals, that is, two input terminals, one output terminal and two power supply terminals.

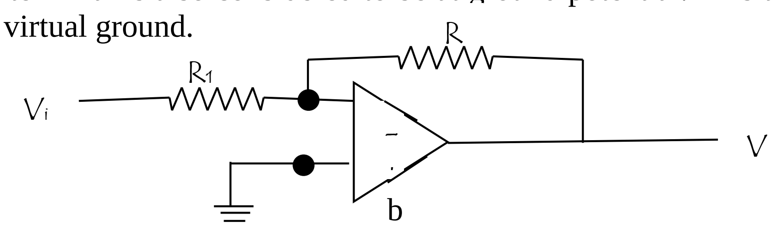
- Inverting input terminal : Pin 2
- Non- inverting input terminal : Pin 3
- Output terminal : Pin 6
- Power supply terminals : Pin 4& 7

1. What is meant by a dual op-amp?

DUAL OP-AMP: When two op-amps are present in a single IC then it is said to be a dual op-amp. The µA 747 is a dual 741 and comes in either a 10-pin can or a 14-pin DIP.

2. Explain the virtual ground concept with a suitable example.

Since the difference between the two input terminals of opamp is zero, as per the ideal characteristics of opamp, the two input terminals must be maintained at the same potential. Thus, if one of the input terminal is at ground potential, then obviously the other terminal is also considered to be at ground potential. This terminal is now said to be at virtual ground.



We know that $V_d = V_a - V_b = 0$;

Node B is grounded

Therefore $V_b = 0$;But $V_d = 0$;$\Rightarrow V_a = V_b$; Node A is at virtual ground. ie since node B is at ground node A is also at virtual ground.

3.What are the factors that affect the stability of an op-amp?

The factors that affect the stability of an op-amp are closed loop gain and phase shift.

4.What are the various methods available for frequency compensation?

*There are two types of compensating techniques used for frequency compensation.
External compensation, internal compensation

*External frequency has two methods for compensation namely
Dominant pole compensation, Pole-zero compensation

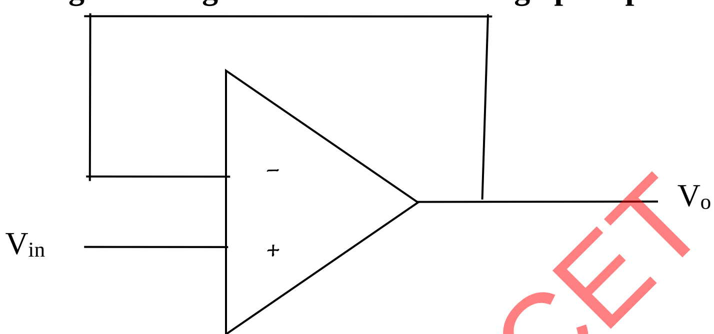
5.Explain the roll off gain in op-amp.

Ideally, an op-amp should have an infinite bandwidth. This means that, if its open loop gain is 90dB with dc signal its gain should remain the same 90dB through audio and on to high radio frequencies. The practical op-amp gain however, decreases (rolls-off) at higher frequencies. This decrease in gain is due to the capacitive component in the equivalent circuit of the op-amp. This capacitance is due to the physical characteristics of the device (BJT or FET) and the internal construction of op-amp.

6.Explain the significance of frequency compensation related to op-amp.

In applications where one desires large bandwidth and lower closed loop gain, suitable compensating techniques are used. The compensating network alters the open-loop gain so that the roll-off rate is –20dB/decade over a wide range of frequency.

7.Design a voltage follower circuit using op-amp



In a non inverting amplifier, if R_f is equal to zero and R_1 is equal to infinity, then the gain of non inverting amplifier becomes unity, $A= 1+(R_f/R_1) = 1$.

8.Mention some applications of op-amp.

Some of the applications of op-amp in open loop mode are as follows:
Comparator, Zero crossing detectors, Window detector, Time marker generator.
Some of the applications of op-amp in closed loop mode are as follows:
Amplifiers, Basic arithmetic operations – summer, subtractor, multiplier, integrator, differentiator, Rectifiers, Waveform generators, Filters

9. What is negative feedback in Op-amp

The feedback circuit connected between the inverting input & the output terminal is called negative feedback.

10. Mention the significance of R_{comp} in an op-amp.

For 741 op-amp, with a 1MΩ feedback resistor, V_o = 500nA x 1MΩ = 500Mv.
The output is driven to 500mV with zero input because of bias currents. This effect can be compensated by adding a compensating resistor between the non-inverting input terminal and ground.

11. Define input offset current and input offset voltage.

INPUT OFFSET CURRENT: The algebraic difference between the currents into the (-) input and (+) input is referred to as input offset current .It is 200nA maximum for 741C.

INPUT OFFSET VOLTAGE: It is the voltage that must be applied between the input terminals of an op-amp to nullify the output. Since this voltage could be positive or negative its absolute value is listed on the data sheet. For 741C, maximum value is 6mV.

12. Define input bias current.

INPUT BIAS CURRENT: The average of currents entering into the (-) input terminal & (+) input terminal of an op-amp is called input bias current. Its value is 500nA for 741C.

13. Define slew rate. Mention its ideal value expected in an op-amp.

SLEW RATE: Slew rate is defined as the maximum rate of change of output voltage caused by a step input voltage and is usually specified is V/µs. An ideal slew rate is infinity which means that op-amp's output voltage should change instantaneously in response to input voltage.

14. Define CMRR AND PSRR. Mention their ideal values.

CMRR: The relative sensitivity of an op-amp to a difference signal as compared to a common mode signal is called common mode rejection ratio and gives the figure of merit ρ for the differential amplifier.

$$\rho = \left| \frac{A_{DM}}{A_{CM}} \right|$$

$$A_{CM} = Voltage\ gain\ \ for\ the\ common - mod\ e\ signal$$

$$A_{DM} = Voltage\ gain\ \ for\ the\ difference\ \ signal$$

CMRR is typically infinite.

PSRR: The change in an op-amp's input offset voltage due to variations in supply voltage is called supply voltage rejection ratio. It is also termed as power supply rejection ratio or power supply sensitivity. For 741C, SVRR=150µV/V. Ideally, it should be zero

15. Explain thermal drift related to an op-amp.

THERMAL DRIFT: Bias current, offset current and offset voltage change with temperature. A circuit carefully nulled at 25^0C may not remain so when the temperature rises to 35^0C.This is called thermal drift. Often current drift is expressed in nA/^{0}C and offset voltage drift in mV/^{0}C.

16. What are the limitations of basic differentiator?

At high frequencies, a differentiator may become unstable and break into oscillation as its gain increases with increasing frequency. The input impedance (ie., $1/\omega C_1$) decreases with increase in frequency, thereby making the circuit sensitive to high frequency noise.

17. What is the limitation of basic integrator?

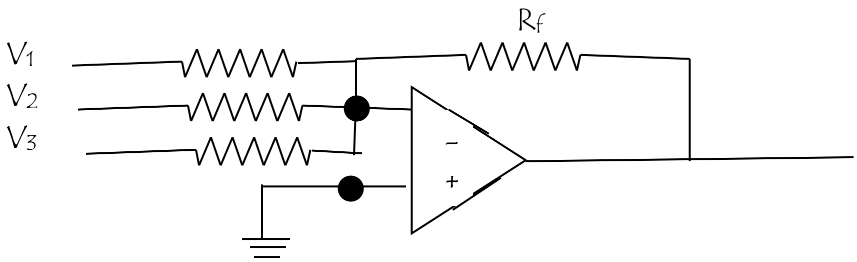
At low frequencies, the feedback capacitor behaves as an open circuit and there is no negative feedback. The op-amp thus operates in open loop, resulting in an infinite gain. In practice, of course, output never becomes infinite, rather the output of the amplifier saturates at a voltage close to the op-amp positive or negative power supply depending on the polarity of the input dc signal.

18. What is the use of differentiator and integrator circuits?

The op-amp differentiator and integrator are useful for signal wave shaping, solving integro-differential equations, wave form generation.

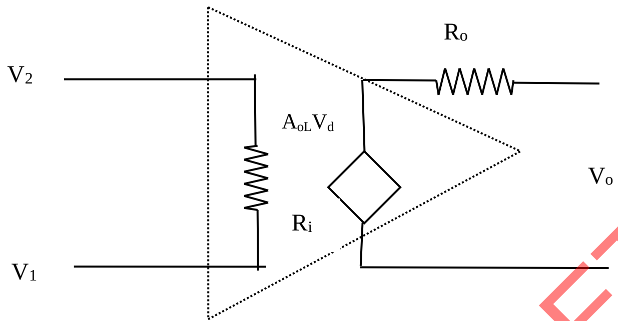
22.What is summing amplifier?

A summing amplifier is a circuit whose output is the sum of several input signals. It may be inverting summing amplifier and non-inverting summing amplifier.



23.What is a practical op-amp? Draw its equivalent circuit.

A physical amplifier is not an ideal one. So, the equivalent circuit of an op-amp may be shown below.



It can be seen that op-amp is a voltage controlled voltage source and $A_{OL} V_d$ is an equivalent Thevenin voltage source and R_o is the Thevenin equivalent resistance looking back into the output terminal of an op-amp.

24. What is the input impedance of a voltage series feedback amplifier?

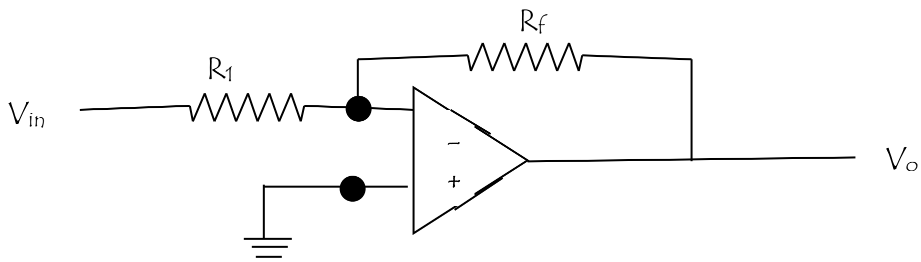
$R_{if}=R_i(1+A\beta)$ where R_{if} is the input resistance with feedback and R_i is the input resistance without feedback of a voltage series feedback amplifier.The input impedance of a voltage series feedback amplifier is extremely large (= infinity) as the op-amp draws negligible current from the signal source.

25. How do you construct a voltage follower circuit and list out the applications?

If the feedback resistance of a non inverting amplifier is made equal to zero and the input resistance is made equal to infinity, then it becomes a voltage follower. The output voltage is equal to input voltage, both in magnitude and phase. In other words, we can also say that the output voltage follows the input voltage exactly. Hence , the circuit is called a voltage follower. It can be used as a buffer for impedance matching as it has high input impedance and low output impedance.

26. Design a circuit using opamp whose gain is -3.

An inverting amplifier can be used with a gain of -3. Let feedback resistance be chosen as10KΩ. Then $A = -R_f/R_1 = -3$. Therfore, R_1 is 3.33KΩ.



27. Why are FET opamps better than BJT opamps?

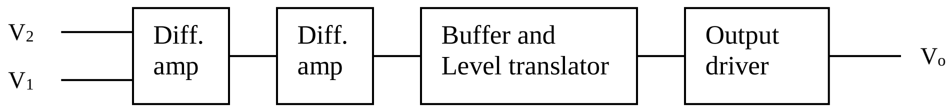
Op-amps using FETs in the input stage offer some very significant advantages over bipolar op-amps, especially in areas as input impedance, input bias and offset currents and slewing rate as shown in table 1.

Parameter	BJT	JFET	MOSFET
Input resistance	KΩ	10^9Ω	10^{12}Ω
Input gate current	µA	1 nA	1 pA
Input offset current	20 nA	2 pA	0.5 pA
Slewing rate	1 V/µs	3 V/µs	10 V/µs

28. Sketch the schematic of an inverting amplifier.

Same figure as in Q.NO.26.

29. Draw the block schematic of an op-amp.

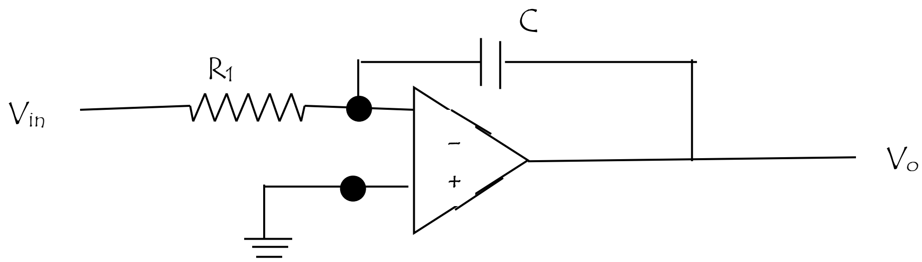


30. List the important specifications of an opamp.

The important specifications of opamp are:

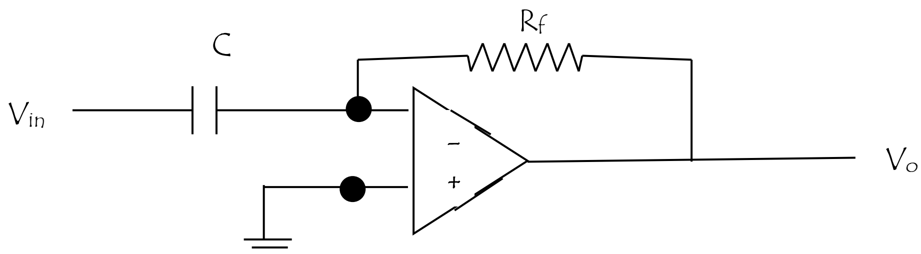
Supply voltage, internal power dissipation, operating temperature range, input offset voltage, input offset current, input bias current, input resistance, input capacitance, CMRR, SVRR, large signal voltage gain, output voltage swing, output resistance and slew rate.

31. How can an opamp be configured to perform integration?



A basic integrator is shown above. $V_o(t) = -1/R_1C \int V_{in}(t)\, dt + V_o(0)$

32. Give the schematic of an opamp differentiator.



A basic differentiator is shown above. $V_0 = -R_fC\, dV_{in}/dt$

33. What is the order of CMRR in dB for opamp ICs?

For 741C, it is typically 90dB.

34. What is the significance of level shifters used internally in an opamp?

Increase in DC level shifts the operating of the next stage which in turn limits output voltage swing and distorts the output. Thus the Quiescent voltage is shifted before it is applied to next stage using level shifters.

35. What are the advantages of using constant current biasing for differential amplifier?

To improve CMRR.

36. Why is R_E replaced by a constant current bias circuit in a differential amplifier?

R_E has to be infinity for high CMRR, but emitter supply must also be increased to maintain proper quiescent current. Else h_{ie} will decrease thereby decreasing h_{fe} too. This will decrease CMRR

37. What is the necessity for an active load in an op-amp?

As op-amp gain increases, phase also increases leading to oscillations, however collector resistance can be increased for obtaining large gain. But there are practical limitations for maximum value of collector resistance and hence the collector resistance is replaced by active load.