



## **Subject Name: Electronic Circuit Analysis**

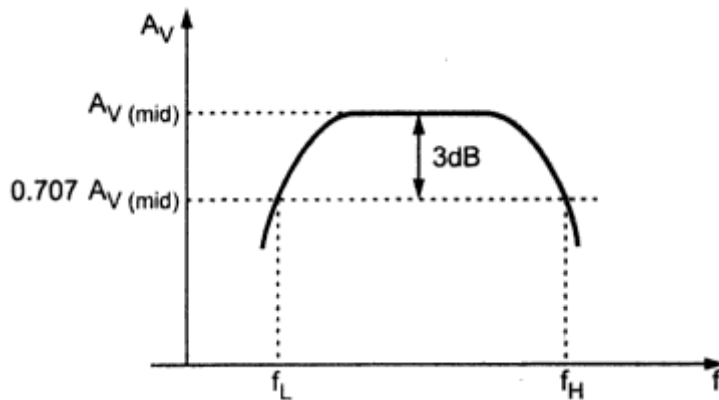
**Prepared by (Faculty (s) Name): M.SREENIVASULU**

**Year and Sem, Department:II & II SEM, ECE**

### **UNIT-I : MULTISTAGE AMPLIFIERS**

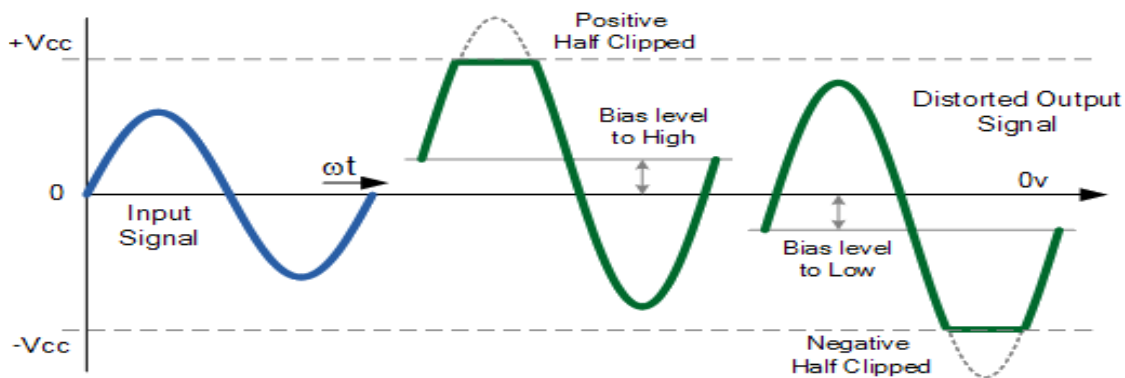
#### **Important Points:**

1. An Amplifier circuit is the one, which changes the characteristics of the input signal, when delivered the output side. The modification in the characteristics of the input signal can be with respect to voltage, current, power or phase. Any one or all these characteristics power, or phase may be changed by the amplifier circuit.
2. A Single-stage Amplifiers has only one transistor circuit and Multi-stage Amplifiers has multiple transistor circuit, which provides single -stage amplification and multi-stage amplification respectively.
3. The amplifier circuit that increases the voltage level of the input signal, is called as Voltage amplifier and the amplifier that increases the power level of the input signal, is called as Power amplifier.
4. When the input signal is so weak so as to produce small fluctuations in the collector current compared to its quiescent value, the amplifier is known as Small signal amplifier.
5. When the fluctuations in collector current are large i.e. beyond the linear portion of the characteristics, the amplifier is known as large signal amplifier.
6. The amplifier circuit that amplifies the signals that lie in the audio frequency range i.e. from 20Hz to 20 KHz frequency range is called as audio amplifier.
7. The amplifier circuit that amplifies the signals that lie in a very high frequency range, is called as Power amplifier.
8. A Multi-stage amplifier circuit that is coupled to the next stage using resistor and capacitor (RC) combination can be called as a RC coupled amplifier.
9. A Multi-stage amplifier circuit that is coupled to the next stage, with the help of a transformer, can be called as a Transformer coupled amplifier.
10. A Multi-stage amplifier circuit that is coupled to the next stage directly, can be called as a direct coupled amplifier.
11. In Multi-stage amplifiers, the output of first stage is coupled to the input of next stage using a coupling device. These coupling devices can usually be a capacitor or a transformer. This process of joining two amplifier stages using a coupling device can be called as Cascading.
12. The range of frequencies over which the gain (voltage gain or current gain) of an amplifier is equal to and greater than 0.707 times the maximum gain is called the bandwidth

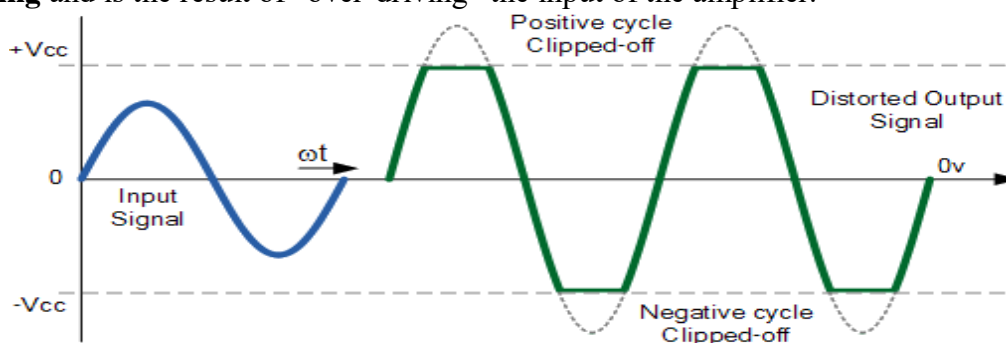


In figure shown,  $f_L$  and  $f_H$  are the lower and upper cutoff frequencies where the voltage or the current gain falls to 70.7% of the maximum gain. Bandwidth  $BW = (f_H - f_L)$ .

13. Amplitude distortion occurs when the peak values of the frequency waveform are attenuated causing distortion due to a shift in the Q-point and amplification may not take place over the whole signal cycle. This non-linearity of the output waveform is shown below.

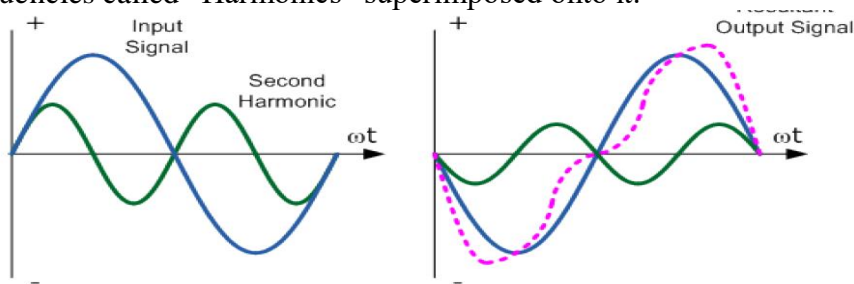


14. The output voltage signal becomes clipped in both the positive and negative parts of the waveform and no longer resembles a sine wave, even when the bias is correct. This type of amplitude distortion is called **Clipping** and is the result of “over-driving” the input of the amplifier.

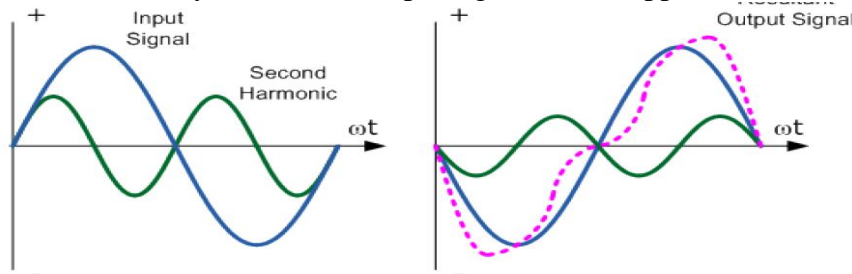


15. **Frequency Distortion** is another type of amplifier distortion which occurs in a transistor amplifier when the level of amplification varies with frequency. Many of the input signals that a practical amplifier

will amplify consist of the required signal waveform called the “Fundamental Frequency” plus a number of different frequencies called “Harmonics” superimposed onto it.



16. **Phase Distortion** or **Delay Distortion** is a type of amplifier distortion which occurs in a non-linear transistor amplifier when there is a time delay between the input signal and its appearance at the output.



17. The cascode amplifier is combined common-emitter and common-base. The cascode improves input–output isolation (reduces reverse transmission), as there is no direct coupling from the output to input. This eliminates the Miller effect and thus contributes to a much higher bandwidth. The use of a cascode is a common technique for improving analog circuit performance.

18. A multi-transistor configuration called the **Darlington configuration** (commonly called a **Darlington pair**) is a compound structure of a particular design made by two bipolar transistors connected in such a way that the current amplified by the first transistor is amplified further by the second one. This configuration gives a much higher current gain than each transistor taken separately.

19. Voltage gain of an amplifier is the ratio of the change in output voltage to the corresponding change in the input voltage.

$$A_V = \Delta V_0 / \Delta V_I$$

20. Current gain of an amplifier is the ratio of the change in output current to the corresponding change in the input current

$$A_I = \Delta I_0 / \Delta I_I$$

21. Power gain of an amplifier is the ratio of the change in output power to the corresponding change in the input power. Where  $p_o$  and  $p_i$  are the output power and input power respectively. Since power  $p = v \times i$ , the power gain is given by

$$A_P = P_O / P_I$$

$$A_P = A_V \times A_I$$



22. The **gain-bandwidth product** for an amplifier is the product of the amplifier's bandwidth and the gain at which the bandwidth is measured.

23. **Unity gain band width** is the frequency at which the output signal is reduced by  $-3$  dB. The amplifier is tested in a unity-gain configuration, with a small signal applied, usually 200 mV p-p. A low level signal is used to determine bandwidth because this eliminates the effects of slew rate limit on the signal.

## IMPORTANT QUESTIONS

### 2-Marks Questions

1. Why is a CE amplifier widely used? List down its main limitations. (Nov-2017 R-13)
2. What are the typical values of h-parameters of CE configuration? (Nov-2017 R-13)
3. What is  $f_T$  of a BJT? (Nov-2017 R-13)
4. Draw a small signal low frequency model of a transistor. (Dec-2017 R-15)
5. State dual of Miller's theorem and also write its applications. (Dec-2017 R-15)
6. What is unity crossover frequency?. (Dec-2017 R-15)
7. Define a short circuit gain of a transistor in CE configuration at high frequencies. (Dec-2017 R-15)
8. Draw the circuit diagram of Darlington Pair. (April-2018-R-15)
9. What is the expression for harmonic distortion in single stage amplifiers? (April-2018-R-15)
10. Define Gain-Bandwidth Product in detail. (April-2018-R-15)
11. How the amplifiers are classified? (Dec-2018-R-15)
12. State and prove Miller's theorem. (Dec-2018-R-15)
13. What is gain bandwidth product? (Dec-2018-R-15)
14. Why emitter bypass capacitor is needed? (Dec-2018-R-15)

### 5-Marks Questions

1. a) Draw the CE amplifier with un bypassed emitter resistance and derive expression for  $R_i$  and  $A_v$ .  
b) A transistor in CB circuit has the following set of 'h' parameters.  $h_{ib} = 20$ ,  $h_{rb} = 0.98$ ,  
 $h_{rb} = 3 \times 10^{-4}$ ,  $h_{ob} = 0.5 \times 10^{-6}$ . Find the values if  $R_i$ ,  $R_o$ ,  $A_i$  and  $A_v$ , if  $R_s = 600 \Omega$  and  $R_L = 1.5 \text{ k}\Omega$ .  
(Nov-2017 R-13)
2. a) Draw the Darlington circuit and derive the expressions for the overall current gain, voltage gain, input impedance and output impedance.  
b) With the help of a neat circuit diagram describe the working of a cascade amplifier.  
(Nov-2017 R-13)
3. a) Draw the hybrid-II model of common emitter configuration and describe each component in the II-model.  
b) Derive the equation for voltage gain bandwidth product for CE amplifier. (Nov-2017 R-13)
4. a) Discuss the effect of different types of loads to a common source MOS amplifier.



- b) Draw the CS FET amplifier equivalent circuit looking into the drain and find its gain and output impedance. (Nov-2017 R-13)
5. a) The h parameters of a transistor used in single stage amplifier circuit are  $h_{ic} = 1100$ ,  $h_{rc} = 1$ ,  $h_{fc} = 51$  and  $h_{oc} = 25\mu A$ . Determine the amplifier parameters for CC configuration when  $R_s = R_L = 10K$ .
- b) For any single-stage amplifier express input resistance in terms of current gain and H-parameters only. (Dec-2017 R-15)
6. a) Derive the bandwidth of a multistage amplifier, assuming that each stage has same upper and lower cut off frequencies.
- b) For the two stage amplifier of the figure 1, calculate the input and output impedance, and the individual and overall voltage gains. Assume  $h_{fe} = 50$ ,  $h_{ie} = 1.1k\Omega$ ,  $h_{re} = h_{oe} = 0$ . (Dec-2017 R-15)
7. a) Discuss about effect of  $C_b$  on frequency response of RC coupled amplifier.
- b) Draw the circuit diagram of Direct Coupled Amplifier and explain its operation in detail. (April-2018-R-15)
8. a) With a neat circuit diagram. Explain about Boot-Strap emitter follower amplifier.
- b) Derive the Analysis of CE amplifier with Emitter Resistance and explain its operation along with circuit diagram. (April-2018-R-15)
9. a) Find the voltage gain, input and output resistances of a emitter follower at high Frequencies.
- b) A common source amplifier uses a MOSFET with the following parameters  $g_m = 1.5mA/V$ ,  $r_d = 40k\Omega$ ,  $C_{gs} = 3pF$ ,  $C_{ds} = 1pF$ ,  $C_{gd} = 3.2pF$ . The value of  $R_d = 200k\Omega$ . The amplifier operates at 30KHz. Find Voltage gain, input resistance, output resistance and input capacitance. (April-2018-R-15)
- 10.a) Draw the circuit diagram of Common source amplifier with Resistive load and explain its operation.
- b) Derive the expression for  $f_T$  of a transistor in detail. (April-2018-R-15)
- 11.a) Draw the equivalent circuit for the CE and CC configurations subject to the restriction that  $R_L = 0$ . Show that the input impedance of the two circuits are identical.
- b) The transistor amplifier shown in figure 1 uses a transistor with typical h parameter values. Calculate  $A_i$ ,  $A_v$ ,  $A_{v_s}$ ,  $R_o$  and  $R_i$ .
- 12.a) Draw the circuit diagram of Darlington emitter follower and derive the expression for input impedance.
- b) Explain the working of cascade amplifier with neat circuit diagram.



13.a) Draw the hybrid  $\pi$  equivalent circuit of a transistor in CE configuration and explain the various parameters in it.

b) A transistor biased at 5mA, 10V,  $h_{ie}=600\Omega$ ,  $h_{fe}=100$ ,  $C_c=3pF$  and current gain of 10 at a frequency of 20MHz. Find  $\beta$  cut off frequency, gain band width product,  $C_e$ ,  $r_{b'e}$  and  $r_{bb'}$ .

(Dec-2017 R-15)

14.a) A transistor biased at 20mA, 20V, it has the h-parameters at room temperature  $h_{ie}=500\Omega$ ,  $h_{fe}=100$ ,  $h_{re}=10^{-4}$ ,  $h_{oe}=4 \times 10^{-5}S$ . It has  $f_T=50MHz$  and  $C_c=3pF$ . Find all the values of hybrid  $\pi$  components.

b) The 3-db bandwidth of an amplifier extends from 20 Hz to 20 kHz. Find the frequency range over which the voltage gain differs by only 1 dB from the mid band value. (Dec-2017 R-15)

### Objective Type Questions:

1. The bandwidth of an amplifier can be increased by [ b ]

- a) Decreasing the capacitance of its bypass capacitors
- b) Minimizing the stray capacitance
- c) Increasing the input signal frequency
- d) Cascading it

2. The main reason for the variation of amplifier gain with frequency is [ a ]

- a) The presence of capacitance internal and external
- b) due to inter stage transformation
- c) The logarithmic increase in its output power
- d) Miller effect

3. The emitter of a CE amplifier has no AC voltage because of the [ c ]

- a) DC voltage unit
- b) Bypass Capacitor
- c) Coupling capacitor
- d) load resistance

4. Typical value of  $h_{ie}$  is [ a ]

- a) 1k
- b) 25k
- c) 50k
- d) 100k

5. A CC-Amplifier has highest \_\_\_\_\_ but lowest \_\_\_\_\_. [ c ]

- a) Voltage Gain and input resistance
- b) output resistance and Current Gain
- c) Current gain and power gain
- d) None of the above

6 In the initial stages of a multi stage amplifier, we use [ a ]

- a) RC coupling
- b) transformer coupling
- c) direct coupling
- d) None

7. The bandwidth of a single stage amplifier is \_\_\_\_ that of a multi stage amplifier. [ a ]



a) more than    b)less than    c)same as    d)none

8.In a RC coupled amplifier, which of the following component is mainly responsible for harmonic distortion of the signal [ d ]

a)Biasing resistor    b)coupling capacitor    c)power supply    d)Transistor

9. The darlington pair consists of the following two stages [ d ]

a) CE,CC    b) CE,CB    c) both CE    d)both CC

10.The gain bandwidth product of a two stage amplifier is [ b ]

a) Same as that of single stage    b) Greater than that of single stage  
c) Less than that of single stage    d) Product of two gain bandwidth products of each stage

11. In a two stage cascaded amplifier, each of two cascaded stages has a voltage gain of 30 then the overall gain is \_\_\_\_\_ [a]

a) 900    b) 0    c)60    d) 1

12) Cascode amplifier is combination of \_\_\_\_\_. [ c ]

a) CC-CB    B)CB-CC    C)CB-CE    D) NONE

13) Why do we go for multi stage amplifiers? \_\_\_\_\_ [ b ]

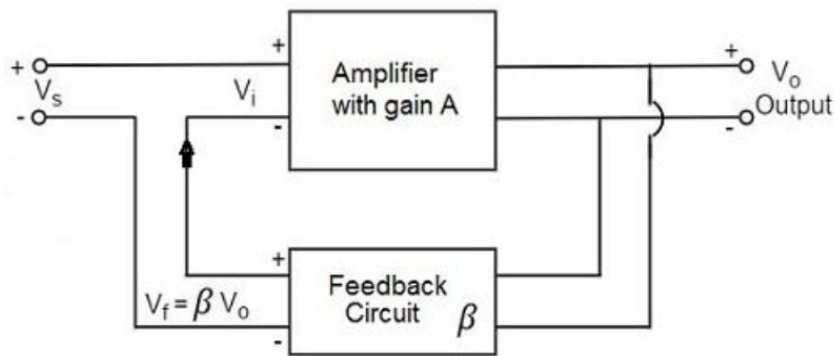
a) For high input impedance    b) for high gain  
c) For high output impedance    d)None

**UNIT-II**

**FEEDBACK AMPLIFIERS**

**Important Points:**

1. The process of injecting a fraction of output energy of some device back to the input is known as **feedback**. The noise in the output of an amplifier is undesirable and must be kept to as small a level as possible. The noise level in amplifiers can be reduced considerably by the use of negative feedback.
- 2 The amplifier introduces a phase shift of  $180^\circ$  into the circuit while the feedback network is so designed that it introduces no phase shift (*i.e.*,  $0^\circ$  phase shift). The result is that the *feedback voltage*  $V_f$  is  $180^\circ$  out of phase with the input signal  $V_{in}$ .
3. Depending upon whether the feedback energy aids or opposes the input signal, there are two basic types of feedback in amplifiers *i.e.* *positive feedback* and *negative feedback*. The block diagram of Feedback amplifier is shown in the figure below.



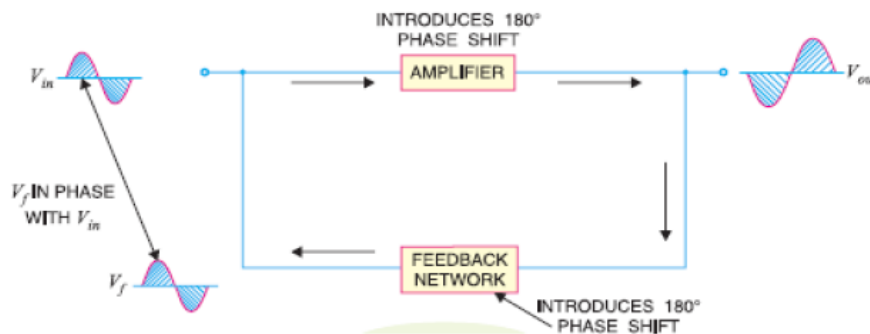
4. The gain of the amplifier is the ratio of output voltage  $V_o$  to the input voltage  $V_i$ . the feedback network extracts a voltage  $V_f = \beta V_o$  from the output  $V_o$  of the amplifier. This voltage is added for positive feedback and subtracted for negative feedback, from the signal voltage  $V_s$ . Now,

$$V_i = V_s + V_f = V_s + \beta V_o$$

$$V_i = V_s - V_f = V_s - \beta V_o$$

The quantity  $\beta = V_f/V_o$  is called as feedback ratio or feedback fraction.

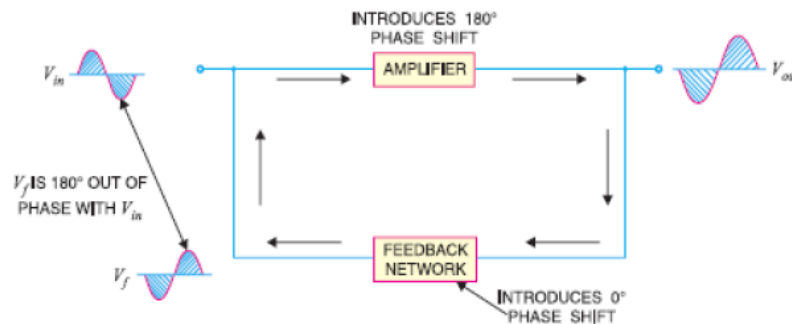
5. When the feedback energy (voltage or current) is in phase with the input signal and thus aids it, it is called *positive feedback*. This is illustrated in Fig.. Both amplifier and feedback network introduce a phase shift of  $180^\circ$ . The result is a  $360^\circ$  phase shift around the loop, causing the *feedback voltage*  $V_f$  to be in phase with the input signal  $V_{in}$ .





6. The positive feedback increases the gain of the amplifier. However, it has the disadvantages of increased distortion and instability. Therefore, positive feedback is seldom employed in amplifiers. One important use of positive feedback is in oscillators.

7. When the feedback energy (voltage or current) is out of phase with the input signal and thus opposes it, it is called *negative feedback*. This is illustrated in Fig.. As you can see, the amplifier introduces a phase shift of  $180^\circ$  into the circuit while the feedback network is so designed that it introduces no phase shift (*i.e.*,  $0^\circ$  phase shift). The result is that the *feedback voltage*  $V_f$  is  $180^\circ$  out of phase with the input signal  $V_{in}$ .



8. The feedback Amplifiers are classified as follows

- i. Voltage series feedback.
- ii. Voltage shunt feedback.
- iii. Current shunt feedback.
- iv. Current series feedback.

9. If the feedback signal is taken across  $R_L$ , it is a  $V_o$  or so it is *Voltage feedback*.

10. If the feedback signal is taken in series with the output terminals, feedback signal is proportional to  $I_O$ , So it is *current feedback*.

11. If the feedback signal is in series with the input, it is *series feedback*.

12. If the feedback signal is in shunt with the input, it is *shunt feedback*.

13. The general characteristics of the Negative feedback amplifier are

- Stability of gain is improved
- Reduction in Distortion
- Reduction in noise
- Increase in input impedance
- decrease in output impedance
- Improves frequency response



## IMPORTANT QUESTIONS

### 2-Marks Questions

1. State Miller's theorem. (Nov-2017 R-13)
2. What are the advantages of negative feedback? (Nov-2017 R-13)
3. What is Class-A power amplifier? (Nov-2017 R-13)
4. Classify power Amplifiers. (Nov-2017 R-13)
5. What is effect of negative feedback on amplifier gain? (Dec-2017 R-15)
6. Draw the Small signal model of MOS amplifier. (April-2018-R-15)
7. Explain different Classification of Feedback Amplifiers (April-2018-R-15)
8. How the stability of amplifier will affect by negative feedback amplifier? (Dec-2018-R-15)

### 5-Marks Questions

1. a) Explain the principle of negative feedback in amplifiers. Show quantitatively the effect of negative feedback on (i) Gain (ii) Stability (iii) Noise (iv) Distortion.  
b) Show that current-series negative feedback increases the input impedance and increases the output impedance. (Nov-2017 R-13)
2. a) The amplifier of figure 2 uses a FET with  $I_{DSS} = 3\text{mA}$ ,  $V_p = -3\text{V}$ ,  $r_d \gg R_d$ . Find the quiescent drain current, quiescent drain to source voltage and  $A_v$ .  
b) Derive the equation for voltage gain of a CS FET amplifier. (Dec-2017 R-15)
3. a) An amplifier has an open loop voltage gain of 1000 and delivers 10W output with 10% second harmonic distortion when the input is 10mV. Find the distortion of 60dB of negative feedback is applied.  
b) Calculate  $A_{vf} = V_o/V_s$ ,  $R_{if}$  and  $R_{of}$  for the circuit shown in figure 3 use typical h parameter values.  $R_s = R_c = 10\text{K}$  and  $R_e = 1\text{K}$ . (Dec-2017 R-15)
4. a) Draw the block diagrams of four types of negative feedback amplifier circuits and explain the advantages and disadvantages with necessary derivations.  
b) Explain why RC Phase shift oscillators are not used at high frequencies. (April-2018-R-15)
5. a) Calculate the voltage gain of the FET amplifier shown in the figure 2. Assuming blocking capacitor to be large.  $g_m = 4\text{mA/V}$  and  $r_d = 5\text{K}$ .  
b) Sketch the small signal model of a CD FET amplifier and derive equation for the voltage gain.
6. a) Draw the negative feedback topologies and explain them.  
b) An open loop amplifier has a midband gain of 500 and a pass band from 50Hz to 50KHz. Find voltage gain and cut off frequencies if 10% of output voltage is fed back.



**OBJECTIVE TYPE QUESTIONS :**

- 1 In a CE amplifier, the unbypassed emitter resistance provides [c]  
a) Voltage shunt feedback    b) Current series feedback  
c) Negative voltage feedback    c) Positive current feedback
- 2 .Negative feedback in amplifier [ b ]  
a) improves SNR at the input    b) improves SNR at the output  
c) Increases distortion    c) None of the above
- 3.The gain of an amplifier with feedback is \_\_\_\_\_. [ a ]  
a)  $A/1+A\beta$     b)  $\beta/1+\beta a$     c)  $\beta/1-\beta a$     d)  $A/1-A\beta$
4. In an ideal voltage amplifier, the values of  $R_i$  &  $R_O$  are \_\_\_\_\_ [b]  
a) 0,  $\infty$     b)  $\infty, 0$     c) 0,0    d)  $\infty, \infty$
5. Negative feedback in amplifier [ b ]  
(a) Improves SNR at the input    (b) improves SNR at the output  
(c) Increases distortion    (d) None of the above
6. In voltage shunt feedback, the input impedance [ b ]  
a)Increases    b)Decreases  
c)Depends on dc voltage applied    d) Depends on frequency of operation
7. One of the effects of negative feedback in amplifier is to [b]  
a) Increase the noise    b) decrease the harmonic distortion  
c )Increase the voltage gain    d)Decrease the bandwidth
8. Negative feedback in amplifier [d]  
a) Increase the gain stability    b) decrease distortion and noise level  
c ) Increase input impedance and decrease output impedance    d)All of these
9. The input impedance of an amplifier can be increased from 2 kilo ohm to 250 kilo ohm by introducing [c]



- a) Shunt current negative feedback
- c ) Series current negative feedback

- b) Shunt voltage negative feedback
- d) None of these

10) The negative feedback as an amplifier

[d]

- a) Increase the voltage gain
- c ) stabilize the voltage gain

- b) decrease the voltage gain
- d) both B and C are correct