(b) The operating range is quite large.

(c) It gives high-fidelity reception,

(d) The efficiency of transmission is very high.

(e) Since FM has a large number of sidebands, it can be used for stereo sound transmission.

Disadvantages

(a) A much wider bandwidth is required by FM. The bandwidth required is 7 to 8 times as large as for AM.

(b) FM transmitting and receiving equipment's are complex, particularly for modulation and demodulation. Therefore, FM is more expensive than AM.

(c) FM reception is limited to line-of-sight.

PROBLEM-SOLVING TACTICS

1. For long distance transmission, we use electrical signals because they can be transmitted at very high speeds $\left(= 3\text{x}10^{8}\,\text{ms}^{-1}\right)$

2. The energy of a wave is directly proportional to its frequency. This permits modulated waves to carry the signals to long distances.

3. In amplitude modulation (AM), the amplitude of high frequency wave is changed in accordance with the intensity of the signal.

$$\text{Modulation factor, } m_a = \frac{\text{Amplitude change of carrier wave}}{\text{Normal carrier wave (unmodulated)}}$$

The value of m depends upon the amplitudes of carrier and signal.

4. In frequency modulation (FM), the frequency of high frequency wave (carrier) is changed in accordance with the intensity of the signal.

$$\text{Modulation Index, } m_f = \frac{\text{Maximum frequency deviation}}{\text{Modulating signal frequency}}$$

5. In AM, the power level of the carrier is not affected by the modulation index m.

6. In phase modulation, the phase angle of the high frequency wave (carrier) is changed in accordance with the strength of the modulating signal.

FORMULAE SHEET

1. In an n-type semiconductor, $n_e \cong N_d >> n_h$ where N_d is the number density of donor atoms.

In a p-type semiconductor, $n_h \cong N_a >> n_e$ where N_a is the number density of acceptor atoms.

In a doped semiconductor (n type or p-type). $n_e n_h >> n_i^2$

Where n_i is number density of intrinsic carriers?

2. In amplitude modulation (AM), the amplitude of high frequency wave is changed in accordance with the intensity of the signal.

$$\text{Modulation factor, } m_a = \frac{\text{Amplitude change of carrier wave}}{\text{Normal carrier wave (unmodulated)}}$$

3. In frequency modulation (FM), the frequency of high frequency wave (carrier) is changed in accordance with the intensity of the signal.

4. $$\text{Modulation Index, } m_f = \frac{\text{Maximum frequency deviation}}{\text{Modulating signal frequency}}$$

5. $$\sigma = e(n_e\mu_e + n_h\mu_h)$$

Where $\sigma = \frac{1}{\rho}$ is called conductivity of the material of semiconductor and μ_e, μ_h are electron and hole mobilities respectively.

6. The equation for diode current is $I = I_o\left(e^{cV/kT} - 1\right)$

Where I_o is called saturation current, V is positive for forward and negative for reverse bias, k is Boltzmann constant, T is temperature and $e = 1.6 x 10^{-19} C$.

7. Half wave Rectifier

Expression for output D.C. Voltage

Output d.c. voltage = Mean load current x load resistance i.e. $V_{d.c.} = I_{d.c.} R_L$. But

Where I_o is the maximum value of the secondary half wave current $\therefore V_{d.c.} = \frac{I_o}{\pi} x R_L$

8. Full-wave Rectifier

Expression for output D.C. Voltage

Output D.C. voltage = Mean load current x load resistance i.e. $V_{d.c.} = I_{d.c.} R_L$ but $I_{d.c.} = \frac{I_o}{\pi}$ where I_o is the maximum value of the secondary half wave current $\therefore V_{d.c.} = \frac{I_o}{\pi} x R_L$

Thus, output D.C. voltage in case of full wave rectifier is twice the output D.C. voltage in case of half wave rectifier.

9. $$\text{a.c. forward resistance, } r_f = \frac{\text{change in forward voltage across diode}}{\text{corresponding change in current through diode}}$$

10. Zener diode voltage regulation

Voltage drop across $R_S = E_{in} - E_o$; Current through $R_S . I = I_z + I_L$

Applying Ohm's law, we have $R_S = \frac{E_{in} - E_o}{I_z + I_L}$

Where R_S is the series resistance that absorbs voltage fluctuations, R_L is the load resistance across which output regulated voltage is desired, I_z is the zener current and I_L is the load current.

11. For a photodiode, $\therefore \quad I_R = mE$ Where m = slope of the straight line

The quantity m is called the sensitivity of the photo-diode.

I_R is the reverse current and E is the illumination of the photo diode.

12. For a transistor, where $I_E = I_B + I_C$ is emitter current, I_B is base current and I_C is collector current.

13. Gains in Common-Base Amplifier

The various gains in a common-base amplifier are as follow:

(i) **ac Current Gain:** It is defined as the ratio of the change in the collector-current to the change in the emitter-current at a constant collector-to-base voltage, and is denoted by α.

Thus $\alpha_{(ac)} = \left(\frac{\Delta i_C}{\Delta i_B}\right)_{V_{CE}}$

The value of α is slightly less than 1 (actually, there is a little current loss).

(ii) **ac Voltage Gain:** It is defined as the ratio of the changes in the output voltage to the change in the input voltage, and is denoted by A.

Suppose on applying an ac input voltage signal, the emitter current changes by Δi and correspondingly the collector-current changes by Δi_C. If R_{in} and R_{out} be the resistances of the input and output circuits respectively, then

$$A_V = \frac{\Delta i_C \, x R_{in}}{\Delta i_E \, x R_{out}} = \frac{\Delta i_C}{\Delta i_E} x \frac{R_{in}}{R_{out}}$$

Now, $\Delta i_C / \Delta i_E$ is the ac current-gain and R_{in}/R_{out} is called the 'resistance gain'.

$\therefore$ Av = $\alpha \times$ Resistance gain

Since the resistance gain is quite high A_V is also high although α is slightly less than 1.

(iii) **ac Power Gain:** It is defined as the ratio of the change in the output power to the change in the input power.

Since power=current x voltage, we have ac power gain = ac current gain x ac voltage-gain = $\alpha^2 \times$ Resistance gain

14. Gain in Common emitter amplifier

(i) dc current Gains: It is defined as the ratio of the collector current to the base current, and is denoted by $\beta(dc) = \frac{i_C}{i_B}$

In a typical transistor, a small base-current $(\approx 10\mu A)$ produces a large collector-current $(\approx 500\mu A)$. Thus $\beta(dc) = \frac{500}{10} = 50$

(ii) ac Current Gain : It is defined as the ratio of the change in the collector-current to the change in the base-current at a constant collector to emitter voltage, and is denoted by

$\beta(ac)$. Thus $\beta(ac) = \left(\frac{\Delta i_C}{\Delta i_B}\right)_{V_{CE}}$

(iii) Voltage gain : Suppose, on applying an ac input voltage signal, the input base-current

Charges by Δi_B and correspondingly the output collector-current changes by Δi_C. If R_{in} and R_{out} be the resistance of the input and the output circuits respectively, then.

$$A_V = \frac{\Delta i_C \times R_{out}}{\Delta i_B \times R_{in}} = \frac{\Delta i_C}{\Delta i_B} \times \frac{R_{out}}{R_{in}} \quad \text{... (i)}$$

Now, $\Delta i_C / \Delta i_B$ is the ac current gain (ac) and R_{in}/R_{out} is the resistance gain

$$\therefore A_v = \beta(ac) \times \text{resistance gain} \quad \text{... (ii)}$$

Since $\beta(ac) >> \alpha(ac)$, the ac voltage gain in common-emitter amplifier is larger compared

To the common-base amplifier, although the resistance gain is smaller.

From equation (i) and (ii), it follows that $A_v = g_m x R_{out}$

(iv) ac Power gain : It is defined as the ratio of the change in the output power to the change in the input power.

Since power=current x voltage, we have ac power gain = ac current gain × ac voltage gain

$= \beta(ac) \times A_v = \beta(ac) \times \{\beta(ac) \times \text{resistance gain}\} = \beta^2(ac) \times \text{resistance gain}$

Since $\beta(ac) >> \alpha(ac)$, the ac power gain in common-emitter amplifier is extremely large

Compared to that in common-base amplifier.

15. The frequency of oscillations is given by $\boxed{v = \frac{1}{2\pi\sqrt{LC}}}$

16. Value of critical frequency in sky wave propagation is given by $f_C = 9(N_{max})^{1/2}$

Where N_{max} =Maximum electron density of ionosphere.

17. Maximum usable frequency, $MUF = \frac{f_C}{\cos\theta} = f_C \sec\theta$

Where θ = Angle between normal and direction of incident waves.

18. Modulation factor, $m_a = \frac{\text{Amplitude change of carrier wave}}{\text{Normal carrier wave (unmodulated)}} = \frac{E_S}{E_C} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$

19. The instantaneous Voltage of AM wave is

$$= E_C \cos\omega_c t + \frac{m_a E_C}{2}\cos(\omega_c + \omega_s)t + \frac{m_a E_C}{2}\cos(\omega_c - \omega_s)t$$

20. In an AM wave, the bandwidth is form $(f_c - f_s)$ to $(f_c + f_s)$ i.e, $2f_s$.

21. Power In AM Wave

The power dissipated in any circuit is a function of the square of voltage across the circuit and the effective resistance of the circuit. Equation of AM wave reveals that it has three components of amplitude $E_C, m_a E_C / 2$ and $m_a E_C / 2$. Clearly, power output must be distributed among these components.

$$\text{Carrier power, } P_C = \frac{\left(E_C/\sqrt{2}\right)}{R} = \frac{E^2 c}{2R} \quad \text{... (i)}$$

$$\text{Total power of sidebands } P_C = \frac{\left(m_a E_C / 2\sqrt{2}\right)^2}{R} = \frac{\left(m_a E_C / 2\sqrt{2}\right)^2}{R} = \frac{m_a^2 E_C^2}{8R} + \frac{m_a^2 E_C^2}{8R} = \frac{m_a^2 E_C^2}{4R} \quad \text{.... (ii)}$$

$$\text{Total power of AM wave, } P_T = P_C + P_S = \frac{E_C^2}{2R} + \frac{m_a^2 E_C^2}{4R} = \frac{E_C^2}{2R}\left[1 + \frac{m_a^2}{2}\right]$$