SOLVED EXAMPLES

Example 1. *A power transistive working in class A operation has zero signal power dissipation of 10 watt. If the a.c. output power is 3 watt, find (i) collector efficiency (ii) Power rating of transistor.*

(i) $$\eta_{collector} = \frac{(P_o)_{ac}}{(P_{tr})_{dc}} = \frac{3}{10} = 0 \cdot 3 = \mathbf{30\%}$$

(ii) Since zero signal condition represents worst case condition for the transistor, it means that the 10 W power is dissipated by it. Hence, transistor power rating is **10 W.**

Example 2. *For class A series fed CE large signal amplifier using resistive load, the maximum and minimum values of collector-emitter voltages are 20 V and 10 V respectively and maximum and minimum values of collector current are 10 mA and 5 mA respectively when an a.c. signal is supplied to it. Determine rms values of collector voltage and collector current and a.c. power output.*

The rms value of collector-emitter voltage

$$(V_{ce})_{max} = \frac{V_{ce(\text{peak to peak})}}{2\sqrt{2}}$$

$$= \frac{(V_{ce})_{max} - (V_{ce})_{min}}{2\sqrt{2}} = \frac{20-10}{2\sqrt{2}} = 3 \cdot 54 \text{ V}$$

The rms value of collector current

$$(I_c)_{max} = \frac{(I_c)_{max} - (I_c)_{min}}{2\sqrt{2}} = \frac{10-5}{2\sqrt{2}} = 1 \cdot 77 \text{ mA}$$

Now a.c. power output

$$(P_o)_{ac} = (V_{ce})_{max} \times (I_c)_{max} = 3{\cdot}54 \times (1 \cdot 77 \times 10^{-3}) = \mathbf{6 \cdot 25 \text{ mW}}$$

Example 3. *A resistive load of 4 Ω is matched to the collector impedance of an amplifier by means of a transformer having turn ratio of 40 : 1. The amplifier uses a D.C. supply voltage of 12 V in the absence of input signal. When signal is present at the base, the collector voltage swings between 22 V and 2 V while the collector current swings between 0·9 A and 0·05 A. Determine (a) collector impedance R_L' (b) signal power output (c) D.C. power input and (d) collector efficiency.*

(a) Here $\frac{n_p}{n_s} = \sqrt{\left(\frac{R_L'}{R_L}\right)}$ or $R_L' = \left(\frac{n_p}{n_s}\right)^2 \times R_L$

$\therefore \quad R_L' = \left(\frac{40}{1}\right)^2 \times 4 = 1600 \times 4 = 6400\,\Omega = \mathbf{6 \cdot 4\ k\Omega}$

(b) Signal power output

$$= \frac{[(V_c)_{max} - (V_c)_{min}] \times [(I_c)_{max} - (I_c)_{min}]}{8}$$

$$= \frac{(22-2) \times (0 \cdot 9 - 0 \cdot 05)}{8} = \frac{17}{8} = \mathbf{2 \cdot 125\ watt}$$

(c) D.C. power input $= V_{cc} \times I_c = 12 \times 0 \cdot 5 = \mathbf{6\ watt}$

(d) Collector efficiency, $\eta = \frac{\text{Signal output power}}{\text{D.C. input power}}$

$$\therefore \quad \eta = \frac{2 \cdot 125}{6} \times 100 = \mathbf{35 \cdot 40\%}$$

Example 4. *For class A, CE amplifier circuit shown in fig. (13·4), $(V_{ce})_Q = 10$ V and $(I_c)_Q = 500$ mA. If the output current varies by ± 250 mA when an input signal is applied at the base, compute the collector efficiency and overall efficiency.*

Here $(P_{in})_{dc} = V_{CC} \times (I_c)_Q = 20 \times 500 = 10^4\ \text{mW} = \mathbf{10\ W}$

$(P_{Rc})_{dc} = (I_c)_Q^{\ 2} \times R_C = (0 \cdot 5)^2 \times 20 = \mathbf{5\ W}$

$(P_{tr})_{dc} = 10\ W - 5\ W = \mathbf{5\ W}$

$(P_o)_{ac} = (I_{rms})^2\ R_C$

Maximum value of output current is 250 mA = 0·25 A

$\therefore \quad I_{rms} = \left(\frac{0 \cdot 25}{\sqrt{2}}\right)$ Amp

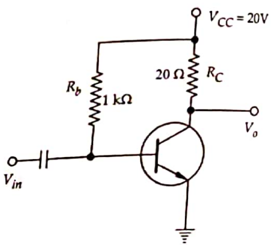

Fig. 13·4

$(P_o)_{ac} = \left(\frac{0 \cdot 25}{\sqrt{2}}\right)^2 \times 20 = \mathbf{0 \cdot 625\ W}$

$(P_c)_{dc} = P_{in}\,(dc) - (P_{Rc})\,(dc) - P_o\ (ac)$

$= 10\ W - 5\ W - 0 \cdot 625\ W = \mathbf{4 \cdot 375\ W}$

Now $\eta_{collector} = \frac{P_{o(ac)}}{P_{tr\,(dc)}} = \frac{0 \cdot 625}{5} \times 100\% = \mathbf{12 \cdot 5\%}$

$\eta_{overall} = \frac{P_{o(ac)}}{P_{in(dc)}} = \frac{0 \cdot 625}{10} \times 100\% = \mathbf{6 \cdot 25\%}$

Example 5. *A regulated power supply shown in fig. (13.5) has an unregulated input (UR) of 15 V and generates a regulated output V_{out}. (i) Calculate the power dissipation across the transistor Q_1.*

(ii) If the unregulated voltage is increased by 20% then what will be the power dissipation across the transistor Q_1? **(GATE 2006)**

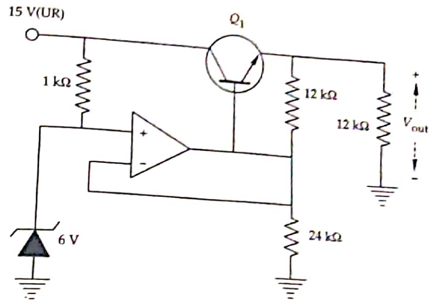

Fig. 13·5

Solution (i). Using the concept of virtual ground, the voltage across 24 kΩ will be 6 V as shown in fig. (13.6).

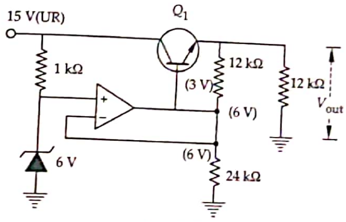

Fig. 13·6

$\therefore$ Voltage across 12 kΩ = 3 V

Now $V_{out} = 6 + 3 = 9$ V

$V_{CE} = 15 - V_{out} = 15 - 9 = 6$ V

Therefore, $I_C = \frac{V_{out}}{12} + \frac{V_{out}}{(24+12)}$

$= \frac{9}{12} + \frac{9}{36} = 1$ A

Power $(P) = V_{CE} \times I_C = 6\text{V} \times 1\text{A} = \mathbf{6\ W}$

(ii) When the unregulated voltage is increased by 20%, then new unregulated voltage becomes 18 V.

$V_{CE} = 18 - 9 = 9$ V and $I_C = 1$ A

$\therefore \quad P = 9 \times 1 = 9$ W

% increase $= \frac{9-6}{6} \times 100 = \mathbf{50\%}$

So, the power dissipation increases by 50%.

SOLVED EXAMPLES

Example 1. *The turn ratio of a transformer is 20 : 1. If a load of 10 Ω is connected across the secondary, what will be the effective resistance seen looking into the primary?*

We know that $R_L' = \left(\frac{n_1}{n_2}\right)^2 R_L$

$$= (20)^2 \times 10 = 4000 = \mathbf{4\ k\Omega}$$

Example 2. *A class A power amplifier uses a transformer as a coupling device. The transformer has a turn ratio of 10 and the secondary load is 10 Ω. If the zero signal collector current is 100 mA, find the maximum power output.*

The effective resistance of the primary of transformer is

$$R_L' = n^2 R_L = (10)^2 \times 10 = 10^3\ \Omega$$

$$(P_o)_{ac} = (I_{rms})^2 \times R_L'$$

For maximum output power $I_{max} = 2 I_c$ and $I_{min} = 0$

$$\therefore \quad I_{rms} = \frac{1}{\sqrt{2}}\left[\frac{I_{max} - I_{min}}{2}\right] = \frac{2 I_c}{2\sqrt{2}} = \frac{I_c}{\sqrt{2}}$$

$$(P_o)_{ac} = \left(\frac{I_c}{\sqrt{2}}\right)^2 \times R_L' = \frac{1}{2}(I_c)^2 R_L' = \frac{1}{2} \times (0 \cdot 1)^2 \times 10^3 = \mathbf{5\ watt}$$

Example 3. *For a power amplifier working in class-A operation, the zero signal collector current is 100 mA. If d.c. supply voltage is V_{cc} = 12 V, determine (a) the maximum a.c. power output, (b) the power rating of transistor, (c) the maximum collector efficiency.*

(a) $(P_{ac})_{max} = \frac{V_{cc} I_c}{2} = \frac{12 \text{ V} \times 100 \text{ mA}}{2} = \mathbf{0 \cdot 6 \text{ watt}}$

(b) D.C. input power, $P_{dc} = V_{cc} \times I_c = 12 \text{ V} \times 100 \text{ mA} = \mathbf{1 \cdot 2 \text{ watt}}$

We know that maximum power is dissipated in the zero signal conditions. Therefore, the power rating of the transistor = **1·2 W**

(c) $\eta = \frac{(P_{ac})_{max}}{P_{dc}} \times 100 = \frac{0 \cdot 6}{1 \cdot 2} \times 100 = \mathbf{50\%}$

Example 4. *For class A, common emitter amplifier, the operating point is located at $I_c = 250$ mA and $V_{CE} = 8$ V. Due to input signal, the output collector current goes in between 450 mA and 40 mA. The V_{CE} swings between 15 V and 1 V. Determine (a) the output power delivered (ii) the input power, (iii) collector efficiency and (iv) power dissipated by the transistor.*

(a) The a.c. power output

$$P_{ac} = \frac{[(V_{CE})_{max} - (V_{CE})_{min}] \times [(I_c)_{max} - (I_c)_{min}]}{8}$$

$$= \frac{(15 - 1) \times (450 - 40)}{8} = \frac{14 \text{ V} \times 410 \text{ mA}}{8} = \mathbf{717 \cdot 5 \text{ mW}}$$

(b) D.C. input power, $P_{dc} = V_{CE} \times I_c$

$\therefore \quad P_{dc} = 8 \times 250 = \mathbf{2000 \text{ mW}}$

(c) $\eta = \frac{P_{ac}}{P_{dc}} \times 100 = \frac{717 \cdot 5}{2000} \times 100 = \mathbf{35 \cdot 87\%}$

(d) $P_{dissipated} = P_{dc} - P_{ac} = 2000 - 717 \cdot 5$

$= 1282 \cdot 5 \text{ mW} = \mathbf{1 \cdot 2825 \text{ W}}$

Example 5. *A class A, CE amplifier operates from $V_{CC} = 20$ V, draws a no signal current of 5 A and feeds a load of 40 Ω through a step-up transformer of $n_2/n_1 = 3 \cdot 16$. Find*

(i) *whether the amplifier is properly matched for maximum power transfer*

(ii) *maximum ac signal power output*

(iii) *maximum d.c. power input*

(iv) *conversion efficiency at maximum signal input.*

(i) $$R_L' = n^2 R_L = \left(\frac{n_1}{n_2}\right)^2 R_L = \left(\frac{1}{3 \cdot 16}\right)^2 \times 40 = 4 \Omega$$

Also $$R_L' = \frac{V_{CC}}{(I_c)_Q} = \frac{20}{5} = 4 \Omega$$

Hence, the amplifier is properly matched.

(ii) $(P_o)_{ac} = \frac{V_{CC}}{\sqrt{2}} \times \frac{(I_c)_Q}{\sqrt{2}} = \frac{V_{CC} \times (I_c)_Q}{2} = \frac{20 \times 5}{2} = \mathbf{50 \text{ W}}$

(iii) $(P_{in})_{d.c.} = V_{CC} \times (I_c)_Q = 20 \times 5 = \mathbf{100 \text{ W}}$

(iv) $\eta = \frac{50}{100} \times 100 = \mathbf{50\%}$

Example 6. *A transformer coupled class A power amplifier draws a current of 200 mA from a collector supply of 10 V, when no signal is applied to it. Determine (i) maximum output power, (ii) maximum collector efficiency and (iii) power rating of transistor. If the load connected across the transformer secondary is of 2Ω and transformer turn ratio is 5 : 1, comment on the impedance matching.*

(i) Maximum output power

$$(P_0)_{ac} = \frac{V_{CC}(I_c)_Q}{2} = \frac{10 \times 0.2}{2} = 1 \text{ W} \qquad (\because (I_c)_Q = 200 \text{ mA} = 0.2 \text{ A})$$

(ii) Maximum collector efficiency

$$\eta_{max} = \frac{(P_0)_{max}}{(P_{in})_{dc}} \times 100$$

$$\text{Here } (P_{in})_{dc} = V_{CC}(I_c)_Q = 10 \times 0.2 = 2\text{W}$$

$$\therefore \qquad \eta_{max} = \frac{1}{2} \times 100 = 50\%$$

(iii) Power rating of the transistor = zero-signal power dissipated

$$= V_{CC}(I_c)_Q = 10 \times 0.2 = 2\text{W}$$

$$\text{Load } R_L = 2\text{W}$$

Load, as seen by transformer primary

$$R_{L'} = n^2 R_L = (5)^2 \times 2 = 50\Omega$$

This is also the ratio of $V_{CC} / (I_c)_Q = \frac{10}{0.2} = 50\ \Omega$

Thus, the load is properly matched.

Example 1. *A sinusoidal signal* $V_s = 1 \cdot 95 \sin 400\, t$ *is applied to a power amplifier. The resulting current is*

$$i_o = 12 \sin 400\, t + 1 \cdot 2 \sin 800\, t + 0 \cdot 9 \sin 1200\, t + 0 \cdot 4 \sin 1600\, t$$

Calculate (a) the total harmonic distortion and (b) the percentage increase in power because of distortion.

(a) The harmonic distortion of each component is given by

$$D_2 = \frac{V_2}{V_1} = \frac{1 \cdot 2}{12} = 0 \cdot 1$$

$$D_3 = \frac{V_3}{V_1} = \frac{0 \cdot 9}{12} = 0 \cdot 075$$

and

$$D_4 = \frac{V_4}{V_1} = \frac{0 \cdot 4}{12} = 0 \cdot 0333$$

The total distortion D is given by

$$D = \sqrt{[D_2{}^2 + D_3{}^2 + D_4{}^2]}$$

$$= \sqrt{[(0 \cdot 1)^2 + (0 \cdot 075)^2 + (0 \cdot 0333)^2]} = 0 \cdot 1294 = 12 \cdot 94\%$$

(b) Total power, $P = [1 + D^2]\, P_1$

$\therefore \quad P = [1 + (0 \cdot 1294)^2]\, P_1 = 1 \cdot 01674\, P_1$

% increase in power due to distortion

$$= \frac{P - P_1}{P_1} \times 100 = \frac{(1 \cdot 01674 - 1)\, P_1}{P_1} \times 100 = 1 \cdot 674\%$$

SOLVED EXAMPLES

Example 1. *A class B push-pull amplifier must deliver 10 W of audio-power to the output load (i) if the output transformer is 80% efficient, what is the minimum power drain on the power supply under optimum conditions and (ii) what is the minimum average dissipation rating required for each transistor?*

The a.c. power output of amplifier is given by

$$(P_o)_{ac} = \frac{\text{Power delivered to load}}{\text{Output transformer efficiency}} = \frac{10}{0 \cdot 8} = 12 \cdot 5 \text{ watt}$$

(i) Minimum power drain on the power supply is given by

$$(P_{in})_{dc} = \frac{(P_0)_{ac}}{\eta} = \frac{12 \cdot 5}{0 \cdot 785} = \mathbf{15 \cdot 9 \text{ watt}} \qquad (\because \text{ efficiency } \eta = 78 \cdot 5\%)$$

(ii) The minimum average power dissipation

$$P_d = (P_{in})_{dc} - (P_0)_{ac} = 15 \cdot 9 - 12 \cdot 5 = 3 \cdot 4 \text{ watt}$$

The minimum average dissipation rating required for each transistor

$$= P_d/2 = 3 \cdot 42 = \mathbf{1 \cdot 7 \text{ watt}}$$

Example 2. *Determine the input power, output power and efficiency resulting in class-B push-pull amplifier providing a signal of 20 V (peak) to a 16Ω load, using single supply of V_{CC} = 30 V.*

Maximum value of collector current

$$(I_c)_{max} = \frac{V_{CC}}{R_L'} = \frac{30}{16} = 1 \cdot 875 \text{ A}$$

$$(P_{in})_{dc} = \frac{2}{\pi} V_{CC} (I_c)_{max} = \frac{2}{\pi} \times 30 \times 1 \cdot 875 = \mathbf{35 \cdot 8 \text{ W}}$$

$$(P_o)_{ac} = \frac{V_{CC}(I_c)_{max}}{2} = \frac{30 \times 1 \cdot 875}{2} = \mathbf{28 \cdot 125 \text{ W}}$$

$$\eta = \frac{(P_o)_{ac}}{(P_{in})_{dc}} \times 100 = \frac{28 \cdot 125}{35 \cdot 8} \times 100 = \mathbf{78 \cdot 5\%}$$