Subjects:

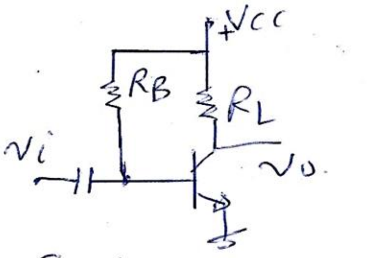
1. Power Amplifiers (class-A, class-B, class-AB and class-C).
2. Differential amplifiers.
3. Operational amplifier applications.
4. Frequency response.
5. Oscillators.
6. Multivibrators (bistable, monostable and astable).
7. Digital circuits (logic families, combinational logic circuit, ROMs, RAMs, A/D and D/A converters).

References:

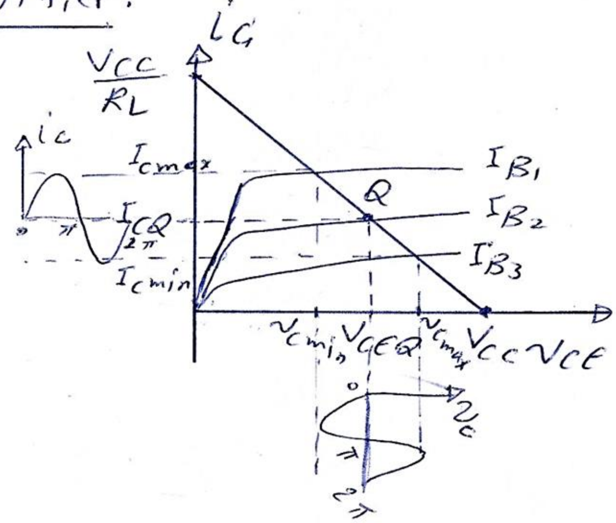
1. Microelectronics digital and analog circuits and systems by Jacob Millman.
2. Electronic circuits discrete and integrated by Schilling.

Audio Frequency Power Amplifier:

1. Class-A Power Amplifier:



Series-Fed
Class-A Power Amplifier



The amplifier is class-A if its output remain in the active region during a complete cycle of a sinewave input signal. $I_{Cmax} \leq I_{CQ}$

In this case is biased at $V_{CEQ} = V_{CC}/2$, which is midway between saturation and cutoff, under these circumstances the non linear distortion is negligible.

- Supplied Power $(P_{cc}) = V_{CC}\, I_{CQ}$
  from D.C. Source
- Power transferred to load $(P_L) = P_{Lac} + P_{Ldc}$

P_{Lac} is the average ac power can be delivered to load. $P_{Lac} = V_{Crms} \times I_{Crms} = \frac{V_{Cmax}\, I_{Cmax}}{2} = \frac{I^2_{Cmax} R_L}{2}$

P_{Ldc} is the dc power delivered to load

$P_{Ldc} = I^2_{CQ} R_L$

- Collector dissipation is the Power dissipated by the device (P_C).

$$P_C = P_{CC} - P_L = P_{CC} - P_{Ldc} - P_{Lac}$$
$$= V_{CC} I_{CQ} - I_{CQ}^2 R_L - \frac{I_{Cmax}^2 R_L}{2}$$
$$= 2 V_{CEQ} I_{CQ} - V_{CEQ} I_{CQ} - \frac{I_{Cmax}^2 R_L}{2}$$
$$= V_{CEQ} I_{CQ} - \frac{I_{Cmax}^2 R_L}{2}$$

$$P_{Cmax}\Big|_{v_i=0} = V_{CEQ} I_{CQ}$$

$v_i = 0$ no signal is present

$$P_{Cmin}\Big|_{I_{Cmax}=I_{CQ}} = \frac{V_{CEQ} I_{CQ}}{2}$$

$$\eta = \frac{\text{average signal Power delivered to load}}{\text{average Power drawn from dc sources}} \times 100\%$$

$$= \frac{P_{Lac}}{P_{CC}} \times 100\% = \frac{I_{Cmax}^2 R_L}{2 V_{CC} I_{CQ}}$$

η_{max} will be when $I_{Cmax} = I_{CQ}$ and $V_{Cmax} = V_{CEQ}$

$$\eta_{max} = \frac{I_{CQ}^2 R_L}{2 V_{CC} I_{CQ}} = \frac{I_{CQ}^2 R_L}{4 V_{CEQ} I_{CQ}} \times 100\% = 25\%$$

The disadvantage of this amplifier is the low efficiency but, the distortion is less than the other type of amplifiers.

Ex: The class-A amplifier is biased at $V_{CE_Q} = 12V$, $R_L = 50\Omega$. The output voltage maximum or peak is 8V. Find the load power, source power, the power dissipated in the collector and the efficiency.

$$P_{Lac} = \frac{I_{Cmax} V_{Cmax}}{2} = \frac{V_{Cmax}^2}{2 R_L} = \frac{(8)^2}{100} = 0.64W$$

$$P_{CC} = V_{CC}\, I_{CQ} = \frac{2V_{CEQ}^2}{R_L}$$

$$= \frac{2(12)^2}{50} = 5.76W$$

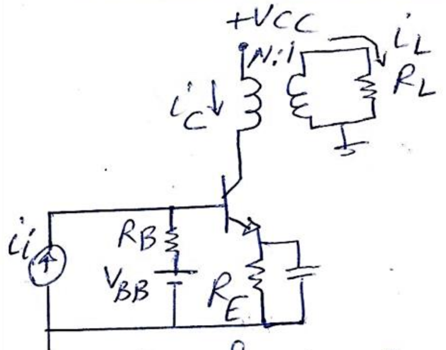
$$P_{Ldc} = \frac{V_{CEQ}^2}{R_L} = \frac{(12)^2}{50} = 2.88W$$

$$P_C = P_{CC} - P_{Lac} - P_{Ldc}$$

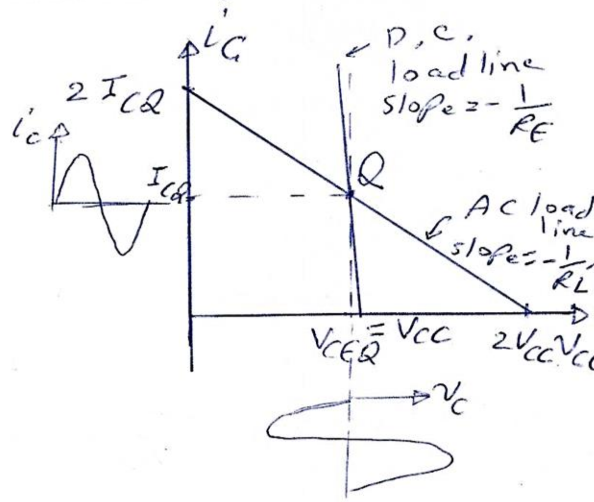
$$= 5.76W - 0.64W - 2.88W = 2.24W$$

$$\eta = \frac{P_{Lac}}{P_{CC}} \times 100\% = \frac{0.64}{5.76} \times 100\% = 11.11\%$$

Transformer Coupled Class-A amplifier:



Transformer Coupled class-A amplifier



A.C. load line

$$v_c = N v_L$$

$$N i_c = -i_L$$

$$\frac{v_c}{-i_c} = N^2 \frac{v_L}{i_L} = N^2 R_L = R_L'$$

R_L': is the load resistance reflected to the Primary side.

$$i_c = -\frac{v_{ce}}{R_L'} \quad \text{ac load line} \quad \text{--}(1)$$

D.C. load line

$$V_{CC} = V_{CEQ} + I_{CQ} R_E$$

$$I_{CQ} = \frac{V_{CC} - V_{CE}}{R_E} \quad \text{--}(2) \quad \text{d.c load line}$$

$V_{CEQ} \simeq V_{CC} \Rightarrow$ at Q point $I_{CQ} = \frac{V_{CC}}{R_L'}$

The maximum swing of the output signal v_{CE} is from 0 (v_{CEmin}) to $2V_{CC}$ (v_{cemax}) $< BV_{CE}$

$I_{Cmax} = 2 I_{CQ} <$ maximum Permissible current.
P-P

- Supplied Power: $P_{CC} = V_{CC} I_{CQ}$
- Power transferred to load: $P_L = P_{Lac} = V_{Lrms} I_{Lrms}$

$$P_L = \frac{I_{Lmax}^2 R_L}{2} = \frac{1}{2} N^2 I_{Cmax}^2 R_L$$
$$= \frac{1}{2} I_{Cmax}^2 R_L'$$

- Collector dissipation:

$$P_C = P_{CC} - P_L = V_{CC} I_{CQ} - \frac{I_{Cmax}^2 R_L'}{2}$$

$$P_{Cmax}\Big|_{I_{Cmax}=0 \text{ (no signal)}} = \frac{V_{CC}^2}{R_L'}$$

$$P_{Cmin}\Big|_{I_{Cmax}=I_{CQ}} = \frac{V_{CC}^2}{R_L'} - \frac{V_{CC}^2}{2R_L'} = \frac{V_{CC}^2}{2R_L'}$$

$$\eta = \frac{P_{Lac}}{P_{CC}} \times 100\% = \frac{\frac{1}{2} I_{Cmax}^2 R_L'}{V_{CC} I_{CQ}} = \frac{\frac{1}{2} I_{Cmax}^2 R_L'}{I_{CQ}^2 R_L'} \times 100\%$$
$$= \frac{1}{2}\left(\frac{I_{Cmax}}{I_{CQ}}\right)^2 \times 100\%$$

$$\eta_{max}\Big|_{I_{Cmax}=I_{CQ}} = 50\%$$

Ex: Transformer coupled Class-A amplifier (6)

$P_{Cmax} = 4W$, $BV_{CEO} = 40V$, $i_{Cmax} = 1A$, with transformer coupling to the 10Ω load, redesign the amplifier for maximum power transfer to the load, specify the required supply voltage, the power dissipated in the load, and the transformer turns ratio: N.

Solution: from the quiescent point which will provide max. power transfer to the load can be obtained.

$$I_{CQ} = \sqrt{\frac{P_{Cmax}}{N^2 R_L}} = \sqrt{\frac{0.4}{N^2}} = \frac{0.63}{N} A$$

$$V_{CEQ} = \sqrt{P_{Cmax} N^2 R_L} = 6.3N\ V$$

$$2I_{CQ} = \frac{1.26}{N} < 1 = i_{Cmax}$$

$$2V_{CEQ} = 12.6N < 40 = BV_{CEO}$$

$$\therefore\ 1.26 < N < 3.17$$

take $N = 2 \Rightarrow I_{CQ} = 0.32A$

$$V_{CEQ} = 12.6V = V_{CC}$$

$$P_{Lmax} = \frac{1}{2}(0.32)^2 (2)^2 10 = 2W$$

$$\frac{1}{2} I_{CQ}^2 R_L'$$