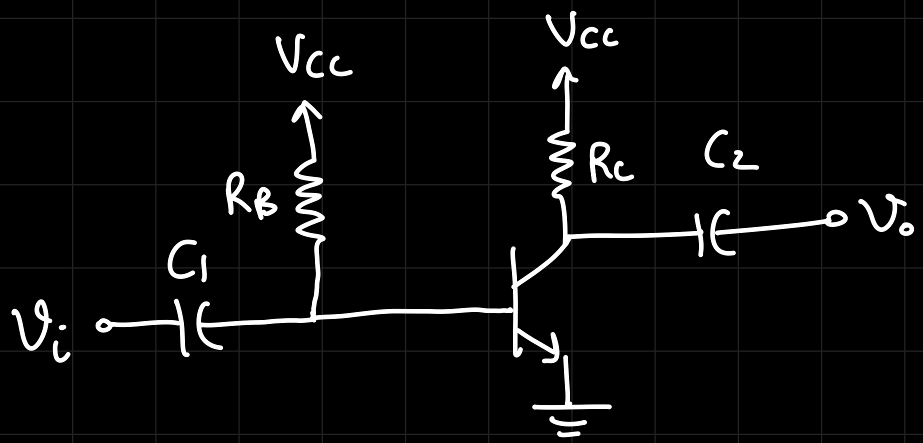
Power Amplifier

1. CLASS A Power Amplifier / Direct coupled Power Amp
2. CLASS A Power Amplifier – Transformer Coupled
3. CLASS B Amplifier – Push Pull Amplifier
4. CLASS C Amplifier

CLASS A Amp / Direct coupled amplifier

it is called direct coupled amplifier because the input and output AC voltage is directly coupled to the Transistor (BJT/MOS)



C_1 and C_2 are coupling capacitors
for DC analysis, all the caps → OC

$$V_{CC} = V_{CE} + I_C R_C$$

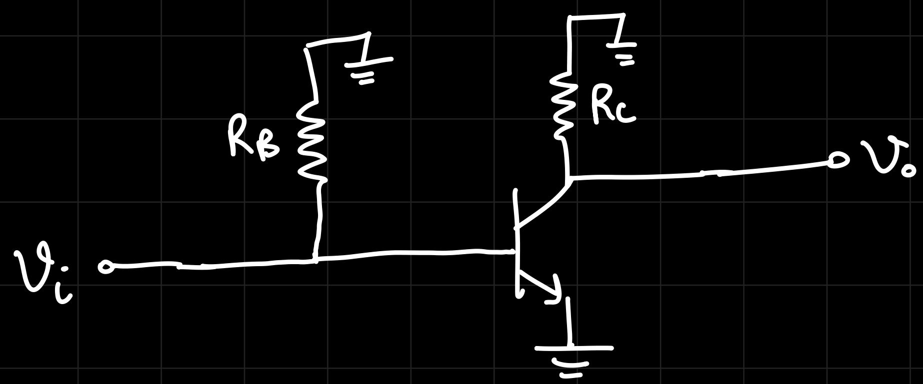
DC load line

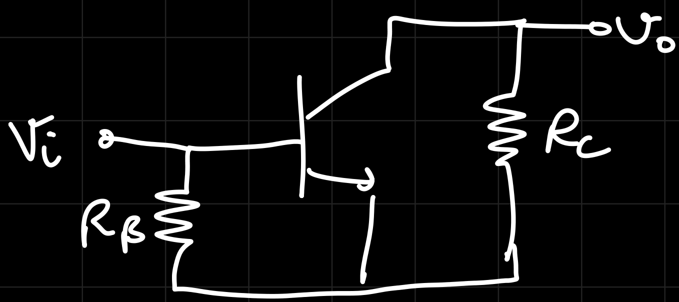
$$I_C = -\frac{1}{R_C} V_{CE} + \frac{1}{R_C} V_{CC} \qquad Q(V_{CE}, I_C)$$

$I_C = 0 \rightarrow V_{CE} = V_{CC}$

$V_{CE} = 0 \rightarrow I_C = \frac{1}{R_C} V_{CC}$

AC analysis:





$$-v_{CE} - \overset{\text{pure AC}}{i_c} R_C = 0$$

$$i_c = \underbrace{-\frac{1}{R_C}}_{\text{slope}} \cdot v_{ce}$$

Note: we got the same slope for

i_c vs v_{CE} and I_{CQ} vs V_{CE}

(pure AC) (pure DC)

$$\overset{\text{AC}}{i_c} = \overset{\text{composite}}{i_C} - \overset{\text{DC}}{I_{CQ}} \quad \text{and} \quad v_{ce} = v_{CE} - V_{CE}$$

$$i_c = \frac{-1}{R_c} v_{ce}$$

$$i_c - I_{CQ} = \frac{-1}{R_c}(v_{CE} - V_{CE,Q}) \quad — \ 3$$

$$(y - y_1) = m(x - x_1)$$

We observe that the Q point remains same for both, the AC case & the DC case

2 × BJT/MOSFET
Cascade/Cascode
CMOS
Power Amp
current mirror
Differential Amplifie

eqn 3 is a generate straight line of slope $\frac{-1}{R_C}$ and is passing through the

Q point (V_{CE}, I_C)

Since the DC and AC load line same slope and both pass through the same point

$$\text{efficiency}: \eta = \frac{P_{dc}}{P_{ac}} \times 100$$

$$P_{dc} = V_{cc} \times I_{CQ}$$

$$P_{ac} = v_{RMS} \times I_{RMS}$$

$$= \frac{V_m}{\sqrt{2}} \times \frac{I_m}{\sqrt{2}}$$

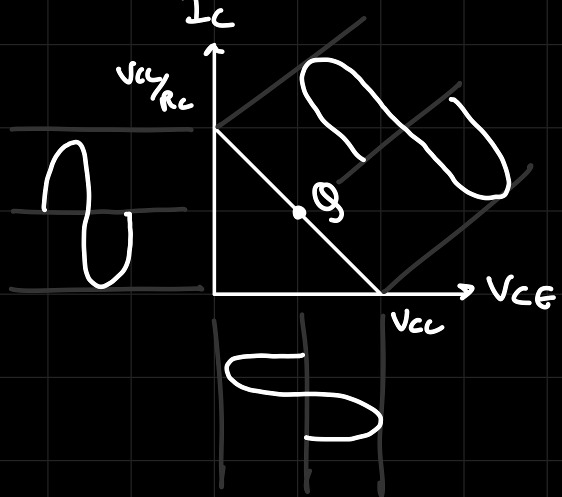
$$= \frac{V_m I_m}{2}$$

$$v_m = \frac{v_{max} - v_{min}}{2} = \frac{V_{cc} - 0}{2} = \frac{V_{cc}}{2}$$

$$I_m = \frac{I_{max} - I_{min}}{2} = \frac{2I_{CQ} - 0}{2} = I_{CQ}$$

$$\eta = \frac{\frac{1}{2} \times V_{cc}/2 \times I_{CQ}}{V_{cc} I_{CQ}} = \frac{1}{4} = \boxed{25\%}$$

for class A amplifier

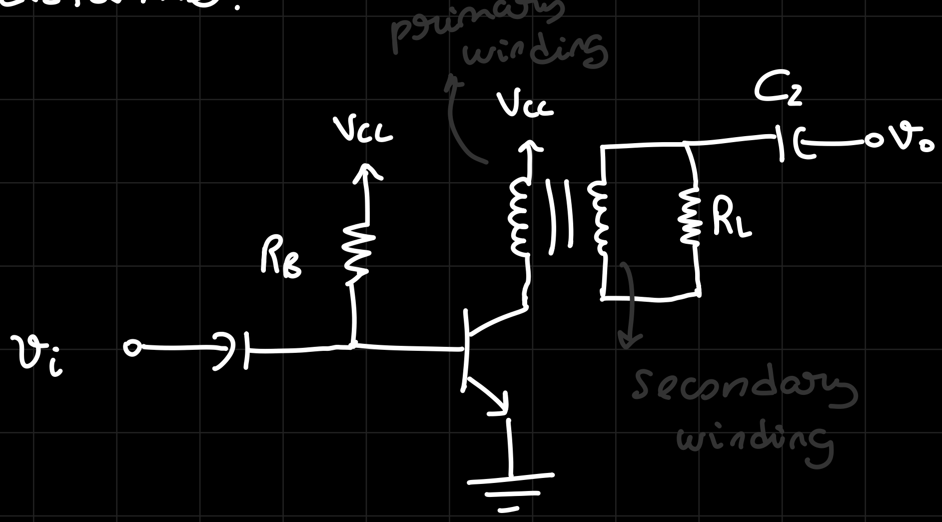


conduction angle : 360°

full swing

CLASS-A / TRANSFORMER COUPLED AMP

In this power amplifier the load is connected to the output node of the amplifier through a transformer.



for DC analysis, all caps → OC

$$X_L = \omega L \ \Omega$$
$$= 2\pi f L \ \Omega$$

for DC → $X_L = 0 \ \Omega$

KVL:
$$V_{CC} = I_C X_L + V_{CE}$$
$$= I_C(0) + V_{CE}$$
$$\underline{V_{CC} = V_{CE}}$$

equation of line parallel to Y axis

∞ slope

$$\frac{V_1}{V_2} = \frac{I_2}{I_1} = \frac{N_1}{N_2} = n$$

↳ $\frac{V_1}{V_2} \times \frac{I_2}{I_1} = n^2$

$$\frac{V_1/I_1}{V_2/I_2} = n^2$$

$$\frac{V_2}{I_2} = R_L \rightarrow \frac{V_1/I_1}{R_L} = n^2$$

let $V_1/I_1 = R_L'$

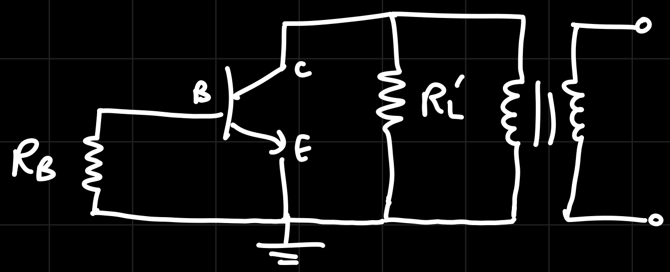
So, $R_L' = n^2 \cdot R_L$

reflected load resistance

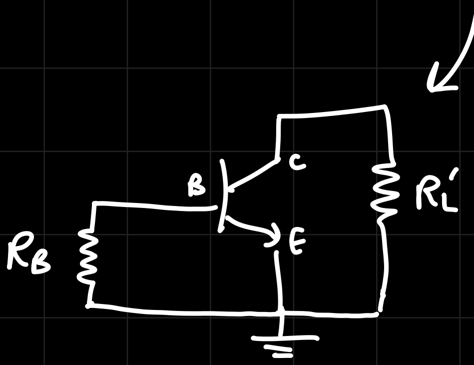
i.e R_L' is the reflection of R_L in primary winding ; we also repleace secondary winding resistance with R_L' in the primary winding.

for AC analysis → caps act as short ckt and deactivate DC src

AC :



at medium frequencies, the inductive reactance of the primary and secondary winding will be large enough therefore, the resistance can be treated as open ckt

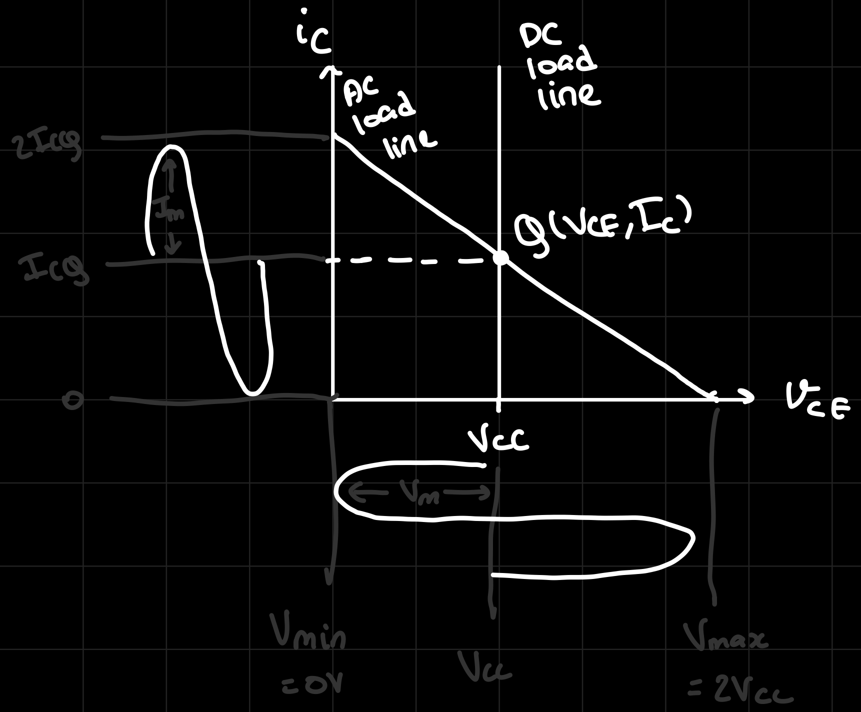


KVL: $i_c R_L' + v_{ce} = 0$

$$i_c = \frac{-1}{R_L'} v_{ce}$$

$$(i_C - I_{CQ}) = \frac{-1}{R_L'}(v_{CE} - V_{CE,Q})$$

$$y - y_1 = m(x - x_1)$$



$$\eta\% = \frac{P_{ac}}{P_{dc}} \times 100$$

$$P_{ac} = \frac{V_m I_m}{2} = \left(\frac{2V_{CC} - 0}{2}\right) \times \frac{1}{2} \times \left(\frac{2I_{CQ} - 0}{2}\right)$$

$$= V_{CC} \times I_{CQ} \times \frac{1}{2}$$

$$P_{dc} = V_{CC} \times I_{CQ}$$

$$\eta = \frac{P_{ac}}{P_{dc}} = \frac{1/2 \times V_{CC} \times I_{CQ}}{V_{CC} \times I_{CQ}} \times 100$$

$$\boxed{\eta = 50\%}$$

conduction angle: 360°

full swing

→ A class A / trasformer coupled amplifier delivers max AC power of 5watt at 4 Ω Load resistance. If the op pnt is located for max symmetrical swing and the DC supply voltage is 20V (V_{cc}).

(1) transformer turn ratio
(2) peak output current
(3) op pnt
(4) Conversion efficiency

Ans)
$$P_{ac} = \frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}}$$

$$V_m = I_m R_L'$$
$$I_m = \frac{V_m}{R_L'}$$

$$P_{ac} = \frac{V_m^2}{2R_L'} \rightarrow$$

$$R_L' = n^2 R_L$$
$$n^2 = \frac{R_L'}{4}$$

Symmetric → $V_m = V_{cc}$ → $R_L' = \frac{\cancel{20}^{2} \times 20}{2 \times 5} = \underline{40\ \Omega}$

$n^2 = 10 \Rightarrow n = \sqrt{10} = \underline{\underline{3.14}} = \frac{N_1}{N_2}$

(b) $I_m = \frac{V_m}{R_L'} = \frac{20}{40} = 0.5A$ | $V_{CE_Q} = V_{cc} = 20V$

$Q(20V, 0.5V)$

$$P_{dc} = V_{CC} \times I_{CQ} = 20 \times 0.5 = 10$$

$$\eta = \frac{P_{ac}}{P_{dc}} \times 100\% = \frac{5}{10} \times 100\% = \underline{50\%}$$