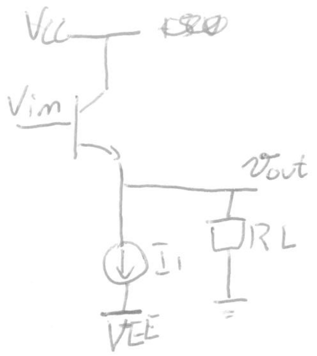
Amplificadores de Potência (Seguidor de Emissor)

$\Rightarrow$ Eficiência (η) $\rightarrow$ entrada senoidal $\Rightarrow v_{in} = V_p \operatorname{sen} \omega t$

$$\eta = \frac{P_{out}}{P_{out} + P_{circ.}}$$



- $I_C \cong I_E = I_1 + \dfrac{v_{out}}{R_L} \overset{A_v \approx 1}{=} I_1 + \dfrac{V_p \operatorname{sen}\omega t}{R_L}$

  $\hookrightarrow I_1 \geq \dfrac{V_p}{R_L}$ (máxima excursão do sinal)

- $V_{CE} = V_{cc} - V_{out} \overset{A_v \approx 1}{=} V_{cc} - V_p \operatorname{sen}\omega t$

- $P_{av_{Q_1}} = \dfrac{1}{T}\displaystyle\int_0^T I_C \cdot V_{CE}\, dt = \dfrac{1}{T}\int_0^T \left(I_1 + \dfrac{V_p \operatorname{sen}\omega t}{R_L}\right)\left(V_{cc} - \overset{V_p \operatorname{sen}\omega t}{V_{out}}\right) dt$

$$P_{av_{Q_1}} = \frac{1}{T}\int_0^T \left[I_1 (V_{cc} - V_p \operatorname{sen}\omega t) + \frac{V_p \operatorname{sen}\omega t}{R_L}(V_{cc} - V_p \operatorname{sen}\omega t)\right] dt$$

$$P_{av_{Q_1}} = \frac{1}{T}\left\{ \int_0^T I_1 \cdot V_{cc}\, dt - \cancel{\int_0^T I_1 V_p \operatorname{sen}\omega t\, dt}^{\,0} + \cancel{\int_0^T \frac{V_{cc} V_p \operatorname{sen}\omega t}{R_L} dt}^{\,0} - \int_0^T \frac{V_p^2 \operatorname{sen}^2 \omega t}{R_L} dt \right\}$$

$$P_{av_{Q_1}} = \frac{1}{T}\left\{ I_1 V_{cc} \cdot t \Big|_0^T - \frac{V_p^2}{R_L} \cdot \int_0^T \overbrace{\frac{(1 - \cos 2\omega t)}{2}}^{\operatorname{sen}^2 \omega t} \cdot dt \right\}$$

$$P_{av_{Q_1}} = \frac{1}{T}\left\{ I_1 V_{cc} \cdot T - \frac{V_p^2}{2 R_L}\left[\int_0^T dt - \int_0^T \cos 2\omega t\, dt\right]\right\}$$

$$P_{av_{Q_1}} = \frac{1}{\cancel{T}} \cdot \left\{ I_1 V_{cc} \cancel{T} - \frac{V_p^2}{2R_L} \cdot \left[\cancel{T} - \emptyset\right]\right\}$$

$$\boxed{P_{av_{Q_1}} = I_1 V_{cc} - \frac{V_p^2}{2R_L}} \xrightarrow[I_1 = \frac{V_p}{R_L}]{\text{Condição mínima} \rightarrow \text{máxima excursão do sinal}} P_{av\,circ} = I_1 \cdot V_{cc} - \frac{V_p I_1}{2}$$

$$\boxed{P_{av_{Q_1}} = I_1\left(V_{cc} - \frac{V_p}{2}\right)} \xrightarrow[V_p = \emptyset]{} \boxed{P_{av_{Q_1}\,MAX} = V_{cc} \cdot I_1}$$

- I_1 pode ser gerada por meio de um transistor

$$P_{av_{I_1}} = \frac{1}{T}\int_0^T I_1 \cdot \underbrace{(\overbrace{V_p \operatorname{sen} \omega t}^{v_{out}} - V_{EE})}_{V_{I_1}}\, dt$$

$$\boxed{P_{av_{I_1}} = -V_{EE} I_1 \quad \hookrightarrow V_{EE} < 0} \xrightarrow{V_{EE} = -V_{CC}} \boxed{P_{av_{I_1}} = V_{CC} I_1}$$

- $P_{circ} = P_{Q_1} + P_{I_1} \Rightarrow \boxed{P_{av\,circ} = I_1\left(2V_{CC} - \frac{V_p}{2}\right)}$

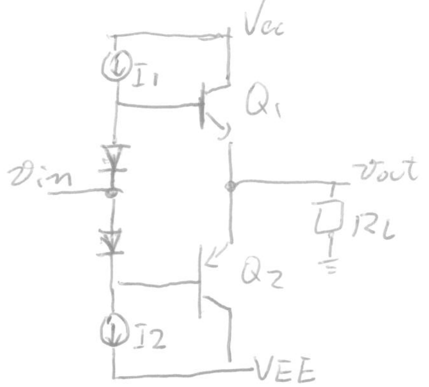
- $P_{out} = P_{RL} \Rightarrow P_{avRL} = \frac{1}{T}\int_0^T \frac{(v_{out})^2}{RL} = \frac{1}{T}\int_0^T \frac{(V_p \operatorname{sen} \omega t)^2}{RL} dt = \frac{V_p^2}{RL.T} \cdot \int_0^T \frac{(1 - \cos 2\omega t)}{2} dt$

$$P_{av\,out} = \frac{V_p^2}{2RL\cancel{T}} \cdot (\cancel{T} - \emptyset) \Rightarrow \boxed{P_{av\,out} = \frac{V_p^2}{2RL}}$$

- $$\eta = \frac{\frac{V_p^2}{2RL}}{\frac{V_p^2}{2RL} + I_1\left(2V_{CC} - \frac{V_p}{2}\right)} \xrightarrow{I_1 = \frac{V_p}{R_L}} \eta = \frac{(V_p^{\cancel{2}}/2RL)}{\cancel{(V_p^2/2RL)} + \frac{2 \cdot V_{CC} \cancel{V_p}}{\cancel{R_L}} - \cancel{\frac{V_p^2}{2RL}}}$$

$$\boxed{\eta = \frac{V_p}{4V_{CC}}}$$

Amplificadores de Potência (Push-Pull)



- entrada senoidal $\Rightarrow v_{in} = V_p \operatorname{sen} \omega t$
- $I_{Q_1} = I_{Q_2} \cong \emptyset$ p/ $v_{out} = \emptyset$
- Cada transistor conduz em apenas metade do ciclo
- $v_{out} = V_p \operatorname{sen} \omega t$; $A_v \sim 1$
- $I_{RL} = \dfrac{v_{out}}{R_L} = \dfrac{V_p \operatorname{sen} \omega t}{R_L}$

$\downarrow$

$I_C \cong I_E$

Q_1 conduzindo

- $V_{CE} = V_{cc} - v_{out} = V_{cc} - V_p \operatorname{sen} \omega t$

- $P_{av_{Q_1}} = \dfrac{1}{T} \displaystyle\int_0^{T/2} V_{CE} \cdot I_C = \dfrac{1}{T} \int_0^{T/2} (V_{cc} - V_p \operatorname{sen} \omega t) \cdot \dfrac{V_p}{R_L} \operatorname{sen} \omega t \, dt$ → meio ciclo

$$P_{av_{Q_1}} = \frac{1}{TR_L} \left\{ \int_0^{T/2} V_{cc} V_p \operatorname{sen} \omega t \, dt - \int_0^{T/2} \underbrace{V_p^2 \operatorname{sen}^2 \omega t}_{V_p^2 \cdot \left(\frac{1 - \cos 2\omega t}{2}\right)} \, dt \right\}$$

$$P_{av_Q} = \frac{1}{TR_L} \left\{ \frac{V_{cc} \cdot V_p}{\omega} \left(-\cos \omega t \Big|_0^{T/2} \right) - \left[\int_0^{T/2} \frac{V_p^2}{2} dt - \underbrace{\int_0^{T/2} \frac{\cos 2\omega t}{2} dt}_{\to \emptyset} \right] \right\}$$

$$P_{av_{Q_1}} = \frac{1}{TR_L} \cdot \left\{ \frac{V_{cc} V_p}{\frac{2\pi}{T}} \left[- \left(\underbrace{\cos \frac{2\pi}{T} \cdot \frac{T}{2}}_{-1} - \underbrace{\cos \emptyset}_{1} \right) \right] - \frac{V_p^2 \cdot T}{4} \right\}$$

$$P_{av_{Q_1}} = \frac{1}{T \cdot R_L} \left\{ + \frac{V_{cc} V_p T \cdot 2}{2\pi} - \frac{V_p^2 T}{4} \right\}$$

$$\boxed{P_{av_{Q_1}} = \frac{V_p}{R_L} \left(\frac{V_{cc}}{\pi} - \frac{V_p}{4} \right)}$$

- $P_{av_{Q_1} \, máx}$

$$\frac{dP_{av_{Q_1}}}{dV_p} = \frac{-2V_p}{4R_L} + \frac{V_{cc}}{\pi R_L} = 0 \Rightarrow \frac{1}{R_L} \cdot \left(\frac{V_{cc}}{\pi} - \frac{V_p}{2} \right) = 0 \Rightarrow V_p = \frac{2V_{cc}}{\pi}$$

→ ponto de máximo

$$P_{av_{Q_1} \, MÁX} = \frac{2V_{cc}/\pi}{R_L} \left(\frac{V_{cc}}{\pi} - \frac{2V_{cc}/\pi}{4} \right) \Rightarrow \boxed{P_{av_{Q_1} \, MÁX} = \frac{V_{cc}^2}{\pi^2 \cdot R_L}}$$

• ~~considerando~~

• desprezando I_{B1} e I_{B2}, podemos desprezar a potência dissipada por I_1 e I_2.

$$\therefore \; P_{av\,circ} = P_{avQ_1} + P_{avQ_2} = 2 . P_{avQ_1}$$

$$\boxed{P_{av\,circ} = \frac{2V_p}{R_L}\left(\frac{V_{cc}}{\pi} - \frac{V_p}{4}\right)}$$

An

→ A potência dissipada na carga é a mesma do seguidor de emissor

$$P_{av_{at}} = \frac{V_p^2}{2R_L}$$

$$\Rightarrow \eta = \frac{\frac{V_p^2}{2R_L}}{\frac{V_p^2}{2R_L} + \frac{2V_p}{R_L}\left(\frac{V_{cc}}{\pi} - \frac{V_p}{4}\right)} = \frac{\frac{V_p^2}{\cancel{2R_L}}}{\frac{V_p^2 + 4V_p\left(\frac{V_{cc}}{\pi} - \frac{V_p}{4}\right)}{\cancel{2R_L}}}$$

$$\eta = \frac{\cancel{V_p^2}}{\cancel{V_p^2} + \frac{4V_pV_{cc}}{\pi} - \frac{\cancel{4}\cancel{V_p^2}}{\cancel{4}}} \Rightarrow \boxed{\eta = \frac{V_p \cdot \pi}{4V_{cc}}}$$