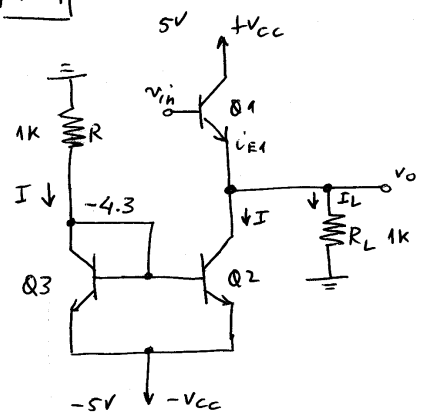
11.1



$V_{BE} = 0.7\,V$

$V_{CE\,sat} = 0.3\,V$

$V_{O\,HIGH} = V_{CE} - V_{CE\,SAT} = +5 - 0.3 = 4.7\,V$

$V_{IN\,HIGH} = V_{O\,HIGH} + 0.7 = +5.4\,V$

$V_{O\,LOW}$:

2 HIPÓTESES

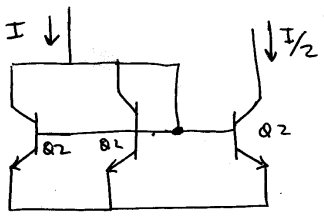
a) Q2 SATURADO

$V_{O\,LOW} = -V_{CC} + V_{CE\,SAT} = -5 + 0.3 = -4.7\,V$

b) Q1 OFF

$+I_L = -I \Rightarrow V_{O\,LOW} = -R_L I = -1\times10^{3} \times \dfrac{4.3}{1\times10^{3}} = -4.3\,V$

$\therefore V_{O\,LOW} = -4.3\,V$ $\quad V_{IN\,LOW} = -4.3 + 0.7 = -3.6\,V$



$V_{O\,LOW} = -R_L \dfrac{I}{2} = -2.15\,V$

$V_{IN\,LOW} = -2.15 + 0.7 = -1.45\,V$

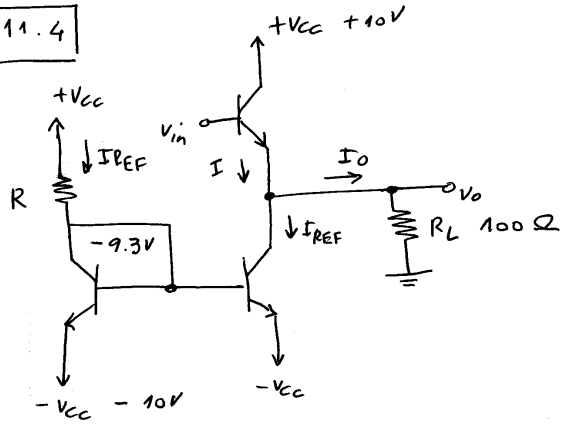
$$\eta = \frac{P_L}{P_S}$$

$$P_{L_{MAX}} = \frac{1}{R} \frac{V_{cc}^2}{2} \qquad \text{(see page 4)}$$

$$P_S = \frac{1}{T} \int_0^T (2 V_{cc}) \times I \, dt = 2 V_{cc} I$$

$$\eta_{MAX} = \frac{P_L}{P_S} = \frac{V_{cc}^2}{4 V_{cc} R I} \Rightarrow I_{MAX} = \frac{V_{cc}}{R} \quad \eta_{MAX} = \frac{1}{4} = 25\%.$$

11.4



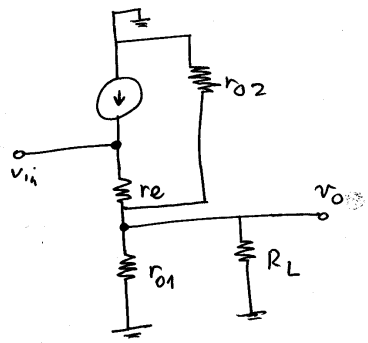
$-5 < v_o < +5V$

$$\frac{I_{REF} + I_O}{I_{REF} - I_O} = 10 \quad ; \quad \frac{I_{REF} + \frac{5}{100}}{I_{REF} - \frac{5}{100}} = 10 \quad ; \quad \frac{I_{REF} + 0.05}{I_{REF} - 0.05} = 10$$

$$I_{REF} + 0.05 = 10\, I_{REF} - 0.5$$

$$0.55 = 9\, I_{REF} \iff I_{REF} = \frac{0.55}{9} = 61\ mA$$

$$R = \frac{V_{cc} - V_c}{I_{REF}} = \frac{10 - (-9.3)}{61 \times 10^{-3}} = 316\ \Omega$$



$$v_o = \frac{R_L \| r_{01} \| r_{02}}{r_e + (R_L \| r_{01} \| r_{02})}\, v_{in}$$

$$v_o \simeq \frac{R_L}{r_e + R_L}\, v_{in}$$

$$A_V \equiv \frac{v_o}{v_{in}} = \frac{R_L}{r_e + R_L}$$

(a) $v_o = +5V$

$$r_e = \frac{V_T}{I} = \frac{V_T}{I_{REF} + \frac{V_o}{R_L}} = \frac{25 \times 10^{-3}}{61 \times 10^{-3} + 50 \times 10^{-3}} = 0.225\ \Omega$$

$$\frac{v_o}{v_{in}} = \frac{100}{0.225 + 100} = 0.9977$$

(b) $$r_e = \frac{V_T}{I_{REF} - \frac{V_o}{R_L}} = \frac{25}{61 - 50} = 2.27\ \Omega$$

$$\frac{v_o}{v_{in}} = \frac{100}{2.27 + 100} = 0.9778$$

$$\frac{\Delta A_V}{A_V} = \frac{0.9977 - 0.9778}{0.9778} = 0.02 \quad (2\%)$$

11.11

$v(t) = V \sin(\omega t)$

$P_i = v(t) \cdot i(t)$ $\qquad i(t) = \dfrac{v(t)}{R}$

$$\bar{P} = \frac{1}{T}\int_0^T P_i(t)\,dt = \frac{1}{R}\,\frac{1}{T}\int_0^T V^2 \sin^2\left(\frac{2\pi}{T}t\right) dt$$

mudança de variável

$$\frac{2\pi}{T}\,t = x$$

$$dt = \frac{T}{2\pi}\,dx$$

p/ $t = T \Rightarrow x = 2\pi$

$$\bar{P} = \frac{1}{R}\,\frac{1}{2\pi}\int_0^{2\pi} V^2 \sin^2 x\,dx \qquad \sin^2 x = \frac{1}{2} - \frac{1}{2}\cos 2x$$

$$\bar{P} = \frac{1}{R}\,\frac{V^2}{2} \qquad \left(V_{eff} = \frac{V}{\sqrt{2}}\right) \qquad \bar{P}_{MAX} = \frac{1}{R}\,\frac{V_{cc}^2}{2} = \frac{1}{100}\,\frac{10^2}{2} = 0.5\ W$$

$$\bar{P}_{S+} = \bar{P}_{S-} = V_{cc}\,\frac{1}{T}\int_0^{T/2} I \sin\left(\frac{2\pi}{T}t\right) dt$$

$$= V_{cc}\,\frac{V_0}{R}\,\frac{1}{2\pi}\int_0^{\pi} \sin x\,dx = \frac{V_{cc}}{\pi}\,\frac{V_0}{R}$$

$$\bar{P}_{S+\,MAX} = \frac{V_{cc}}{\pi}\,\frac{V_{cc}}{R} = \frac{1}{3.14}\,\frac{10^2}{100} = 0.318\ W$$

$$\eta = \frac{P_L}{P_S} = \frac{P_L}{2 \times P_{S+}} = \frac{0.5}{2 \times 0.318} = 78.6\,\%$$

PARA $V_0 = \frac{V_{cc}}{2} = 5$

$$P_L = \frac{1}{R}\frac{V_o^2}{2} = \frac{1}{100}\frac{5^2}{2} = 0.125\ W$$

$$P_{S+} = \frac{V_{cc}}{\pi}\frac{V_o/2}{R} = \frac{10}{3.14}\frac{5}{100} = 0.159\ W$$

$$\eta = \frac{P_L}{2\,P_{S+}} = \frac{0.125}{2 \times 0.159} = 39\%$$

11.13

$$\bar{P} = \frac{1}{R}\frac{V_o^2}{2} \qquad 100 = \frac{1}{16}\frac{V_o^2}{2} \qquad V_o = 56.5\,V$$

$$V_{cc} = V_o + 4 = 56.5 + 4 = 60.5\ V \longrightarrow 61\ V$$

$$I_{peak} = \frac{V_o}{R} = \frac{56.5}{16} = 3.53\ A$$

$$\bar{P}_{S+} = \bar{P}_{S-} = \frac{V_{cc}}{\pi} I_{peak} = \frac{61}{3.14} \times 3.53 = 68\ W$$

$$\bar{P}_S = \bar{P}_{S+} + \bar{P}_{S-} = 136\ W$$

$$\eta = \frac{100}{136} = 73.5\%$$

Transistor power dissipation

$$P_D = P_S - P_L$$

$$= \frac{2}{\pi} \frac{V_o}{R_L} V_{CC} - \frac{1}{R_L} \frac{V_o^2}{2}$$

P_D máx:

$$\frac{\partial P_D}{\partial V_o} = 0 \qquad 0 = \frac{2}{\pi} \frac{V_{CC}}{R_L} - \frac{V_o}{R_L} \qquad \Rightarrow V_o = \frac{2 V_{CC}}{\pi}$$

$$P_{D\,máx} = \frac{2 V_{CC}^2}{\pi^2 R_L}$$

$$P_{DN} = P_{DP} = \frac{V_{CC}^2}{\pi^2 R_L} = \frac{61^2}{3.14^2 \times 16} = 23\,W$$