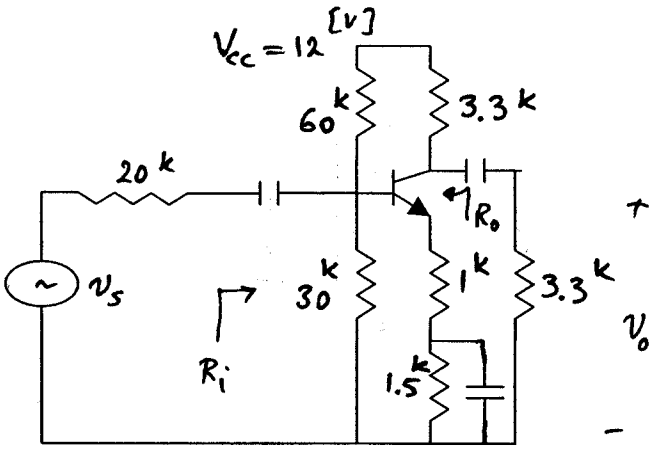
ECE3455, Q5) In the amplifier shown, beta=100, and VA=∞

a) Find the ICQ and VCEQ of the BJT.
b) Find the BJT parameters r_π and g_m .
c) Draw the small signal model of the amplifier.
d) Find the voltage gain V_o/V_s .
e) Find the input and output resistance.

Note: Capacitors are open for DC and short for AC signals.

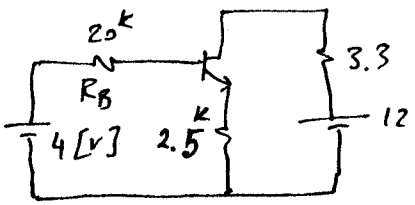


$V_{BE(on)} = 0.7\ [V]$

$V_T = 25\ mV$

solution :

(a) DC values can be found from the DC circuit shown $\Rightarrow$ writing a KVL in the input loop

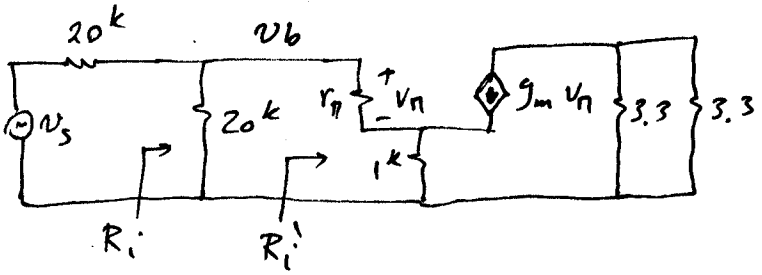


$4 = 20\,\frac{I_E}{101} + 0.7 + 2.5 \times I_E \qquad I_E = I_{CQ} = 1.22\ mA$

$V_{CEQ} = 12 - (2.5+3.3) \times 1.22 = 4.92\ [V]$

b) $r_\pi = \frac{\beta V_T}{I_C} = \frac{100 \times 25}{1.22} = 2.049\ [k\Omega] \qquad g_m = \frac{I_C}{V_T} = \frac{1.22}{25} = 48\ mv$

c) The small signal (or AC) model of amplifier shown $\Rightarrow$



d) $R_i' = r_\pi + 1\,(101) = 103\ k\Omega$

$R_i = 20^k \,||\, R_i' = 20 \,||\, 103 = 16.75\ [k\Omega]$

$v_b = \frac{16.75}{20+16.75} v_s = 0.455\, v_s \Rightarrow v_\pi = \frac{r_\pi}{R_i'} v_b = \frac{2.049}{103} v_b$

$v_\pi = \frac{2.049}{103} \times 0.455\, v_s = 9.05 \times 10^{-3} v_s \Rightarrow \frac{v_\pi}{v_s} = 9.05 \times 10^{-3}$

$v_o = -g_m v_\pi \times 3.3 \,||\, 3.3 \Rightarrow \frac{v_o}{v_\pi} = -48 \times 1.65 = -79.2$

$\frac{v_o}{v_s} = \frac{v_\pi}{v_s} \times \frac{v_o}{v_\pi} = 9.05 \times 10^{-3} \times (-79.2) = -0.716$

e) $R_i = 16.75\ [k\Omega]$ as calculated in Part (d)

$R_o = R_c = 3.3\ [k\Omega]$