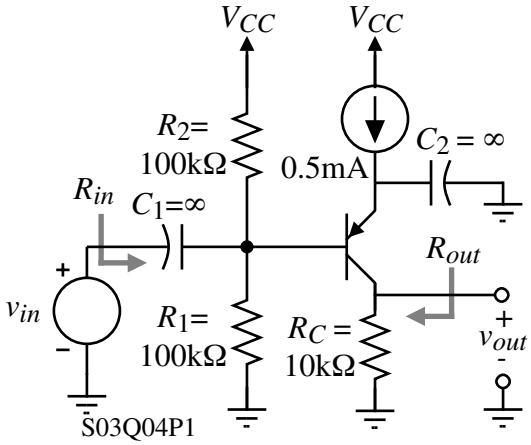
# QUIZ NO. 4 - SOLUTION

(Average score = 7.9/10 of the students taking the quiz.)

A PNP BJT common-emitter inverting amplifier is shown. Assume the parameters of the transistor are $\beta_F = 50$, $V_T = 25\text{mV}$, and $V_A = 100\text{V}$. (a.) Find the small signal model parameter values for $g_m$, $r_\pi$, and $r_o$ (ignore $V_{EC}$ in the calculation of $r_o$). (b.) Find an algebraic expression for the small signal voltage gain, $v_{out}/v_{in}$, the input resistance, $R_{in}$, and the output resistance, $R_{out}$. (c.) Numerically evaluate the small signal voltage gain, $v_{out}/v_{in}$, the input resistance, $R_{in}$, and the output resistance, $R_{out}$.



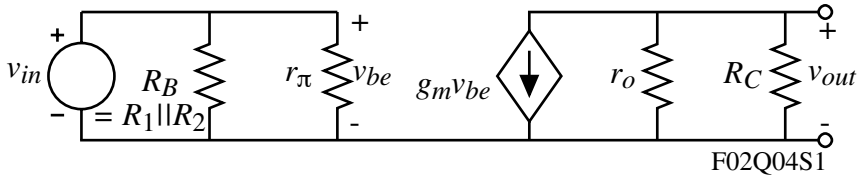

*Solution*

(a.) $$I_C = \frac{50}{51}(0.5\text{mA}) = 0.49\text{mA}$$

$$g_m = \frac{I_C}{V_T} = \frac{0.49\text{mA}}{25\text{mV}} = \underline{19.6\text{mS}}$$

$$r_\pi = \beta_F \frac{V_T}{I_C} = \frac{50}{19.6\text{mS}} = \underline{2.55\text{k}\Omega} \qquad r_o = \frac{V_A}{I_C} = \frac{100}{0.49\text{mA}} = \underline{204\text{k}\Omega}$$

(b.) To find the small signal voltage gain, we must first develop a small signal model. This model is given below:




$$\boxed{\frac{v_{out}}{v_{in}} = \frac{v_{out}}{v_{be}} = -g_m(r_o \| R_C)} \qquad \boxed{R_{in} = R_1 \| R_2 \| r_\pi} \quad \text{and} \quad \boxed{R_{out} = r_o \| R_C}$$

(c.) The numerical value of the above expressions are,

$$\frac{v_{out}}{v_{in}} = -19.6\text{mS}(204\text{k}\Omega \| 10\text{k}\Omega) = -19.6\text{mS}(9.533\text{k}\Omega) = \underline{-186.84\ \text{V/V}}$$

$$R_{in} = 100\text{k}\Omega \| 100\text{k}\Omega \| 2.55\text{k}\Omega = \underline{2.426\text{k}\Omega}$$

and

$$R_{out} = 204\text{k}\Omega \| 10\text{k}\Omega = \underline{9.533\text{k}\Omega}$$