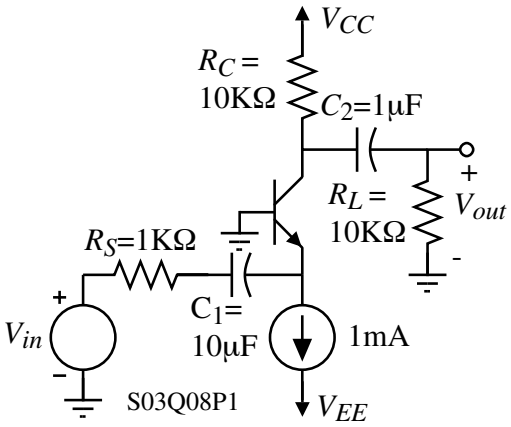
QUIZ NO. 8 - SOLUTION

(Average score = 6.4/10 of those taking the quiz.)

A BJT amplifier is shown. Assume that the BJT has the small signal parameters of β_F = 100, V_t= 25mV, and $V_A = \infty$.

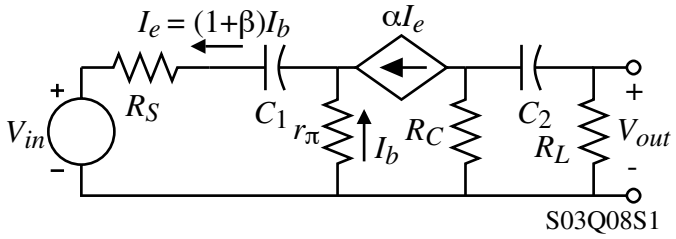
a.) Find the midband voltage gain of this amplifier, V_{out}/V_{in}.

b.) Find the value of the lower -3dB frequency, f_L, in Hz, using any method that is appropriate.



Solution

Small-signal model for this problem:



$$g_m = \frac{1\text{mA}}{25\text{mV}} = 40\text{mS}$$

$$r_\pi = \frac{\beta_F}{g_m} = 2.5\text{k}\Omega$$

Use the direct approach:

$$\frac{V_{out}}{V_{in}} = \left(\frac{V_{out}}{I_e}\right)\left(\frac{I_e}{V_{in}}\right) = \left(\frac{-\alpha_F R_C R_L}{R_C + R_L + \frac{1}{sC_2}}\right)\left(\frac{-1}{R_S + \frac{1}{sC_1} + \frac{1}{g_m}}\right)$$

$$= \left(\frac{\alpha_F R_C R_L}{R_C + R_L}\right)\left(\frac{g_m}{1+g_m R_S}\right)\left(\frac{s}{s + \frac{1}{C_2(R_C + R_L)}}\right)\left(\frac{s}{s + \frac{1}{C_1\left(R_S + \frac{1}{g_m}\right)}}\right)$$

$$\therefore \quad MBG = \left(\frac{\alpha_F R_C R_L}{R_C + R_L}\right)\left(\frac{g_m}{1+g_m R_S}\right) = (5\text{K})\left(\frac{40\text{mS}}{1+40}\right) = \frac{200}{41} = \underline{\pm 4.878\text{V/V}}$$

$$\omega_1 = \frac{1}{C_1\left(R_S + \frac{1}{g_m}\right)} = \frac{10^6}{10(1000 + 25)} = 97.56 \text{ rads/sec.}$$

$$\omega_2 = \frac{1}{C_2(R_C + R_L)} = \frac{10^6}{1(20\text{K})} = 50 \text{ rads/sec.}$$

Since ω_1 and ω_2 are within an octave of each other then there is no dominant root so that we will simply sum the roots which is identical with the short-circuit time constant approach to give, ω_L as,

$$\omega_L \approx \omega_1 + \omega_2 = 147.56 \text{ rads/sec.} \quad \rightarrow f_L \approx \underline{23.5 \text{ Hz}}$$