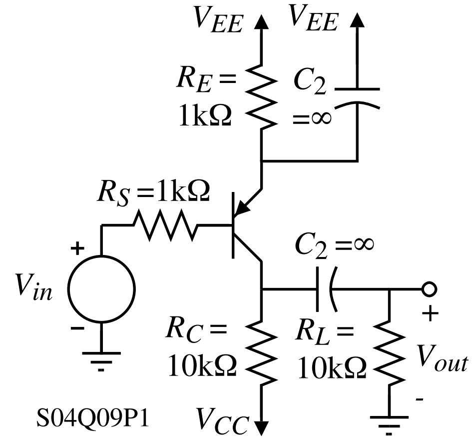
QUIZ NO. 9 – SOLUTION

(Average score = 8.2/10 for those taking the quiz.)

A BJT transistor amplifier is shown. If g_m = 20mA/V, $r_{„}$ = 5kΩ, C = 1pF, and $C_{„}$ = 5pF, find (1) numerical values for the midband gain (MBG), (2) the upper -3dB frequency in Hertz using Miller's approach and (3) the upper -3dB frequency in Hertz using the open-circuit time constant approach.



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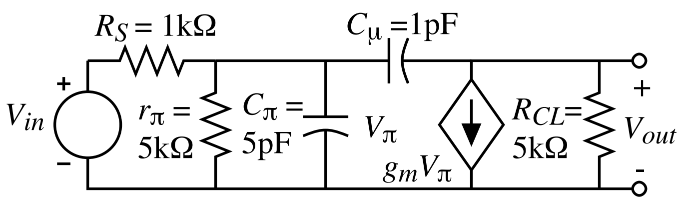
Solution

The small signal model is given as,



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(1) Let the capacitors be removed for the MBG. As a result we can write,

$$\frac{V_{out}}{V_{in}} = \left(\frac{V_{out}}{V_\pi}\right)\left(\frac{V_\pi}{V_{in}}\right) = (-g_m R_{CL})\left(\frac{r_\pi}{r_\pi + R_S}\right) = (-100)\left(\frac{5\text{k}\Omega}{1\text{k}\Omega+5\text{k}\Omega}\right) = \underline{\underline{-83.33\text{V/V}}}$$

(2) Using the Miller approach:

$$\omega_H = \frac{1}{(r_\pi \| R_S)[C_\pi + C_\mu(1+g_m R_{CL})]} \quad \text{assuming that } \frac{1}{\omega_H C_\mu} >> R_{CL}.$$

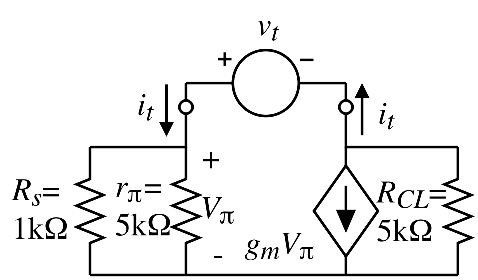
$$\therefore \quad \omega_H = \frac{1}{(0.833\text{k}\Omega)[5\text{pF}+1\text{pF}(101)]} = 11.32 \text{ Mrads/sec.} \rightarrow \underline{\underline{f_H = 1.80\text{MHz}}}$$

Note that $\frac{1}{\omega_H C_\mu}$ = 88.34kΩ so that the assumption is valid.

(3) Using the open-circuit time constant approach:

$R_{c\pi O} = r_\pi \| R_S = 0.8333\text{k}\Omega$

$R_{c\mu O}$:



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$$V_t = I_t(r_\pi \| R_S) + (I_t + g_m V_\pi)R_{CL}$$

$$V_t = I_t(r_\pi \| R_S) + I_t R_{CL} + g_m R_{CL}(r_\pi \| R_S) I_t$$

$$R_{c\mu O} = \frac{V_t}{I_t} = (r_\pi \| R_S)(1 + g_m R_{CL}) + R_{CL}$$

$$= 0.8333\text{k}\Omega(101) + 5\text{k}\Omega = 89.167\text{k}\Omega$$

$$\therefore \quad \omega_H = \frac{1}{R_{c\pi O}C_\pi + R_{c\mu O}C_\mu} = \frac{1}{0.833\text{k}\Omega \cdot 5\text{pF} + 89.167\text{k}\Omega \cdot 1\text{pF}} = 10.71 \text{ Mrads/sec.}$$

$\underline{\underline{f_H = 1.71\text{MHz}}}$