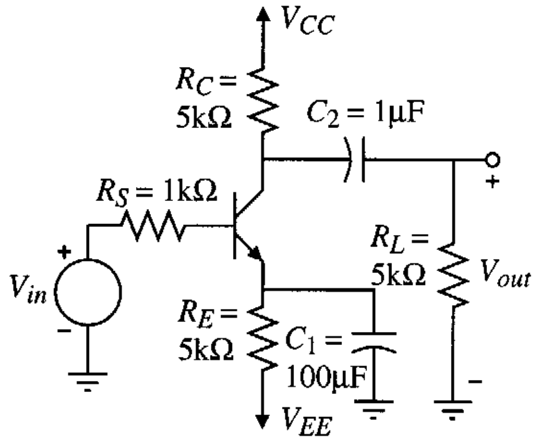
QUIZ NO. 10 - SOLUTION

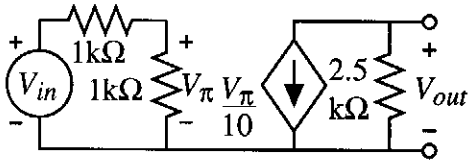
(Average Score = 7.0/10 for only those who took the quiz.)

A BJT transistor amplifier is shown. If g_m = 100mA/V, r_π = 1kΩ, C_μ = 1pF, and C_π = 20pF, find numerical values for the midband gain (MBG) and the upper -3dB frequency (ω_H).

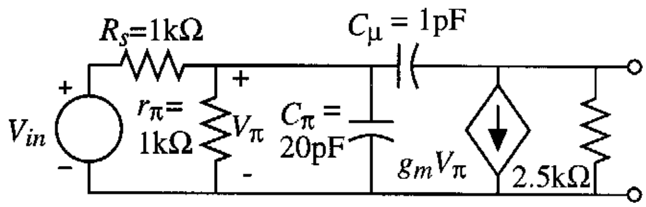


Solution

Midband gain: Small signal model-



$$\text{MGB} = (0.5)\left(\frac{-2500}{10}\right) = -125 \text{ V/V}$$



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High frequency response:

1.) Use the Miller approach.

$$\frac{V_o}{V_\pi} = -g_m(2.5\text{k}\Omega) = -250$$

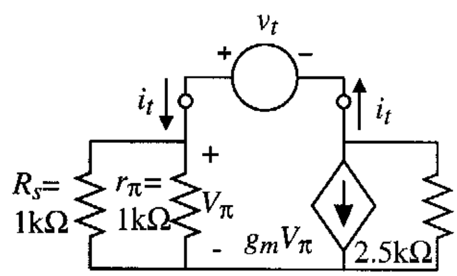
$C_{eq} = C_\pi + (251)C_\mu = 20\text{pf} + 251\cdot 1\text{pF} = 271\text{pF}$ and $R_{eq} = 1\text{K}||1\text{K} = 500\Omega$

$$\therefore \quad \omega_H = \frac{1}{500\cdot 271\text{pF}} = 7.38\text{x}10^6 \text{ rads/sec} \Rightarrow f_H = 1.175 \text{ MHz}$$

2.) Open-Circuit Time Constant Approach.

$R_{C\pi} = R_s || r_\pi = 500\Omega$

$R_{C\mu}$ = ? See model.



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$$v_t = V_\pi + (i_t + g_m V_\pi)2.5\text{k}\Omega$$

$$= V_\pi(1 + g_m 2.5\text{k}\Omega) + i_t 2.5\text{k}\Omega$$

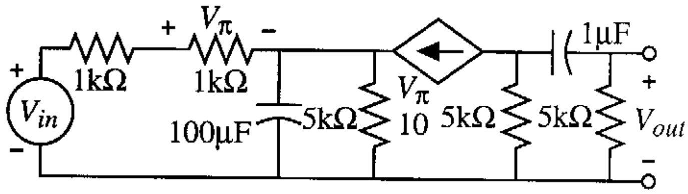
$$= i_t (R_s||r_\pi)(1 + g_m 2.5\text{k}\Omega) + i_t 2.5\text{k}\Omega$$

$$\therefore \quad R_{C\mu} = \frac{v_t}{i_t} = 0.5\text{k}\Omega(251) + 2.5\text{k}\Omega = 128\text{k}\Omega$$

$$\omega_H = \frac{1}{R_{C\pi}C_\pi + R_{C\mu}C_\mu} = \frac{10^9}{0.5\text{x}20 + 128\text{x}1} = 7.246\text{x}10^6 \text{ rads/sec.} \Rightarrow f_H = 1.15 \text{ MHz}$$

The open-circuit time constant approach agrees reasonably well with the Miller approach.

Low frequency response (Not required): Small signal model-



Use the superposition approach which will be exact because C_1 and C_2 are electrically isolated.

C_1: A bypass capacitor.

$$\text{Zero} = \frac{1}{5k\Omega \cdot 100\mu F} = 2 \text{ rads/sec} \quad \text{Pole} = \frac{1}{100\mu F\left(\frac{2k\Omega}{101} \| 5k\Omega\right)} = \frac{1}{100\mu F \cdot 19.7} = 507 \text{ rads/sec}$$

C_2: A coupling capacitor. (Zero is at origin)

$$\text{Zero} = 0 \text{ rads/sec} \qquad \text{Pole} = \frac{1}{1\mu F(5k\Omega + 5k\Omega)} = 100 \text{ rads/sec}$$

$$\omega_L \approx \sqrt{(507)^2 + (100)^2 - 2(2)^2} = 517 \text{ rads/sec} \Rightarrow f_L = 82.3 \text{ Hz}$$