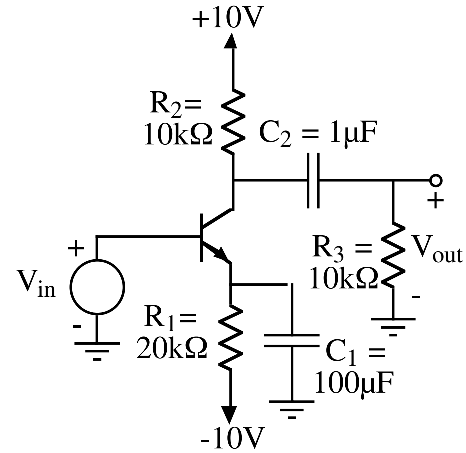
QUIZ NO. 8 - SOLUTION

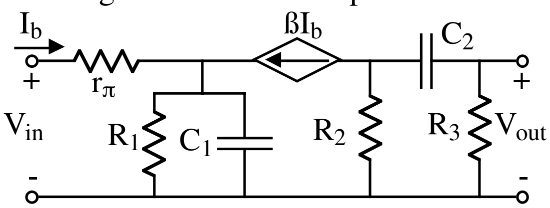
(Average score = 7.5/10 of those taking the quiz.)

r_π and β of the BJT shown are 1kΩ and 100, respectively. Find the numerical value of all zeros, poles, and the midband gain for the voltage transfer function, $V_{out}(s)/V_{in}(s)$. What is the lower -3dB frequency?



Solution

The small signal model for this problem is:



$$\frac{V_{out}}{V_{in}} = \left(\frac{V_{out}}{I_b}\right)\left(\frac{I_b}{V_{in}}\right) = \left(\frac{-\beta R_2 R_3}{R_2+R_3+\frac{1}{sC_2}}\right)\left(\frac{1}{r_\pi+(1+\beta)\left(\frac{R/sC_1}{R_1+\frac{1}{sC_1}}\right)}\right)$$

$$= \left(\frac{-\beta R_2 R_3}{r_\pi(R_2+R_3)}\right)\left(\frac{s}{s+\frac{1}{C_2(R_2+R_3)}}\right)\left(\frac{s+\frac{1}{R_1C_1}}{s+\frac{r_\pi+(1+\beta)R_1}{r_\pi R_1 C_1}}\right) = A_o\left(\frac{s}{s+\omega_2}\right)\left(\frac{s+\omega_1}{s+\omega_1'}\right)$$

where

$$A_o = \frac{-\beta\cdot R_2\|R_3}{r_\pi} = \frac{-100\cdot 5\text{k}\Omega}{1\text{k}\Omega} = -500\text{V/V}$$

$$\omega_1 = \frac{1}{R_1C_1} = \frac{1}{20\text{k}\Omega\cdot 100\mu\text{F}} = 0.5 \text{ rads/sec}$$

$$\omega_1' = \omega_1\left(1+\frac{(1+\beta)R_1}{r_\pi}\right) = 0.5\left(1+\frac{101\cdot 20}{1}\right) = 1010 \text{ rads/sec}$$

and

$$\omega_2 = \frac{1}{C_2(R_2+R_3)} = \frac{1}{20\text{k}\Omega\cdot 1\mu\text{F}} = 50 \text{ rads/sec}$$

Therefore,

Zeros at s=0 and s=-0.5 rad/sec

poles at s = -50 rads/sec and s = -1010 rads/sec

Midband gain = A_o = -500V/V

The lower -3dB frequency is

$$\omega_L = \sqrt{50^2+1010^2 - 2(0.5^2)} = 1018 \text{ rads/sec or } f_L = 161 \text{ Hz}$$