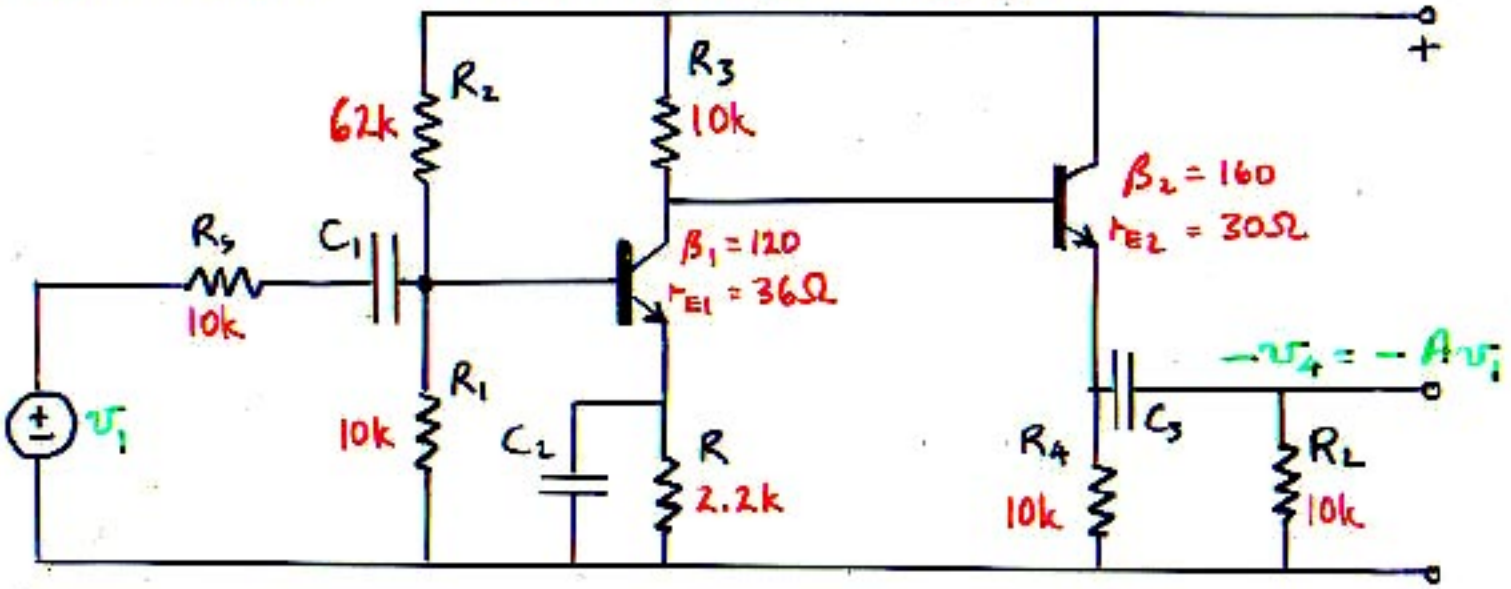
EXERCISE 7.1

SOLUTION

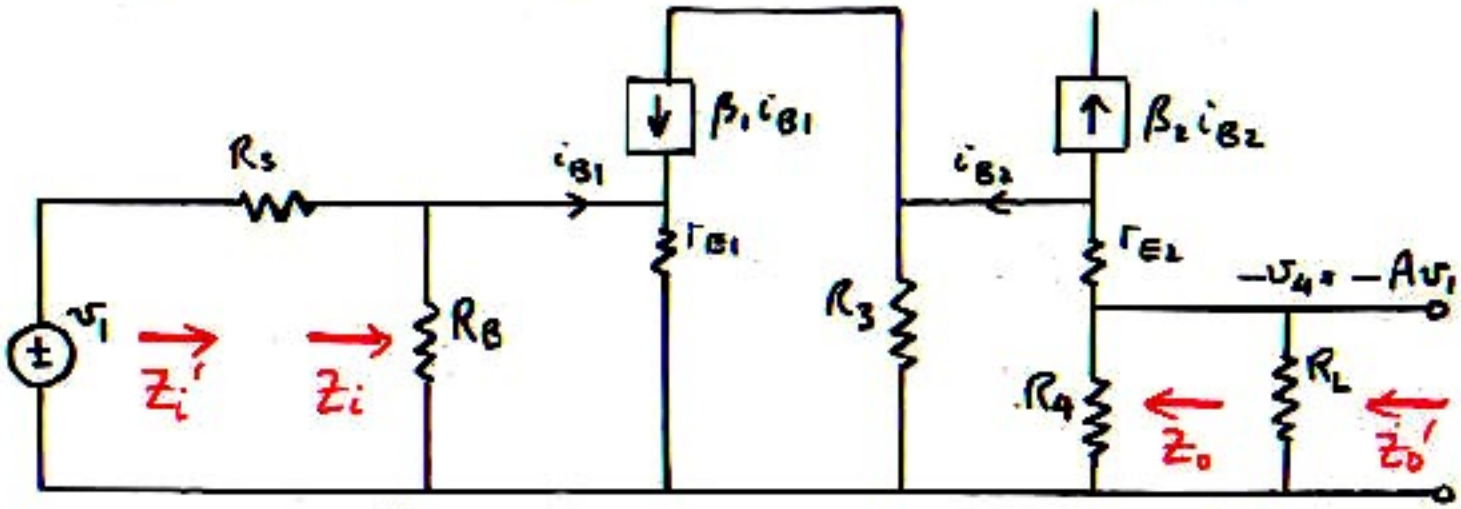
Example

Draw the small-signal equivalent circuit model of the common-emitter — emitter-follower amplifier:



Find the midband gain $A \equiv v_4/v_i$ analytically and numerically.

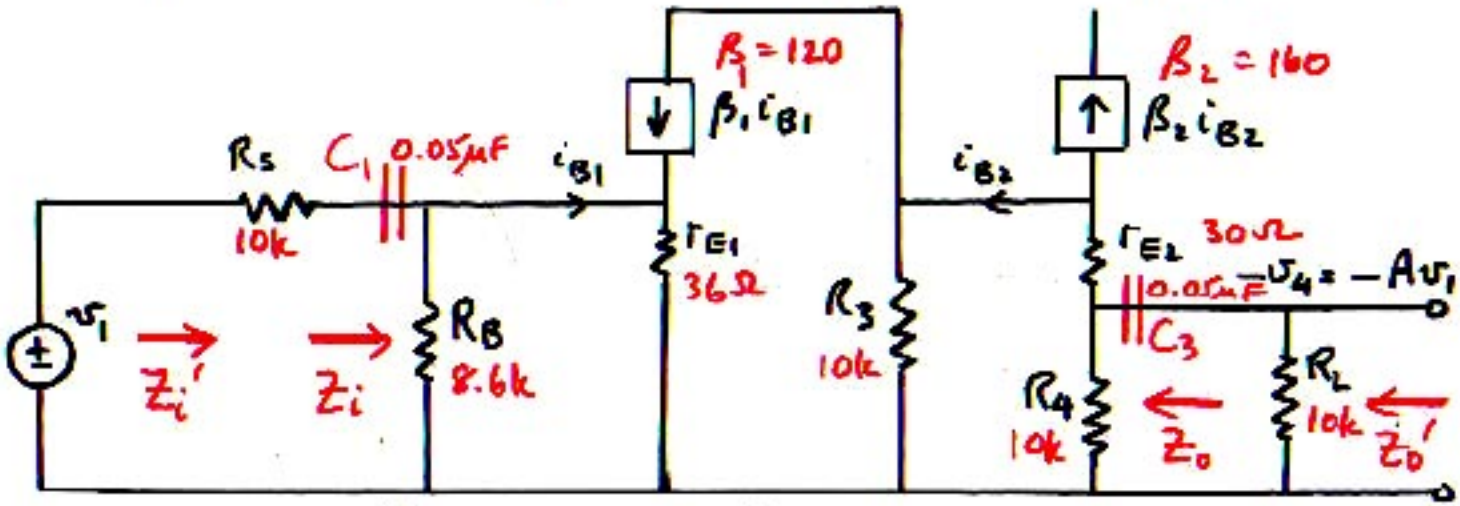
Example: the CE plus emitter follower amplifier



$$A_m = \frac{R_B}{R_B + (1+\beta_1) r_{E1}} \cdot \frac{\beta_1 R_3}{R_3 + R_B \| (1+\beta_1) r_{E1}} \cdot \frac{R_4 \| R_L}{R_4 \| R_L + r_{E2} + R_3/(1+\beta_2)}$$

$K_1 \uparrow$ $\quad K_2 \uparrow$ $\quad K_3 \uparrow$

Example: the CE plus emitter follower amplifier



$$A_m = \frac{R_B}{R_B + (1+\beta_1) r_{e1}} \cdot \frac{\beta_1 R_s}{R_s + R_B \| (1+\beta_1) r_{e1}} \cdot \frac{R_4 \| R_L}{R_4 \| R_L + r_{e2} + R_3/(1+\beta_2)}$$

$K_1 \uparrow$ $K_2 \uparrow$ $K_3 \uparrow$

Exercise Find the gain in factored pole-zero form when the coupling capacitances C_1 and C_3 are included. Evaluate the corner frequencies, and sketch the magnitude asymptotes.

Exercise Solution

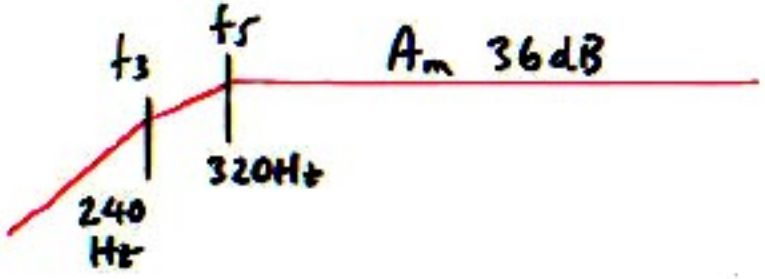
$$A = A_m \frac{1}{\left(1+\frac{\omega_3}{s}\right)\left(1+\frac{\omega_5}{s}\right)}$$

$$\omega_3 \equiv \frac{1}{C_1\left[R_s + R_B \| (1+\beta_1) r_{E_1}\right]} = \frac{159}{0.05\left[10 + \underbrace{8.6 \| 4.3}_{2.9}\right]}$$

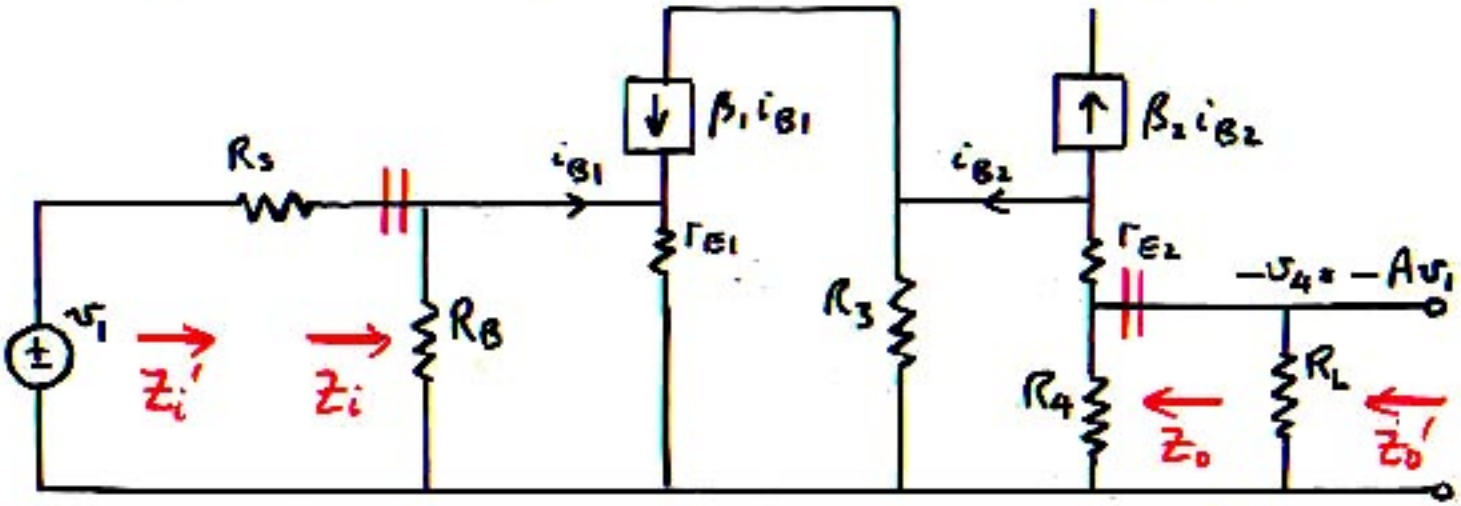
$$\approx 240 \text{ Hz}$$

$$\omega_5 \equiv \frac{1}{C_3\left[\left(r_{E_2} + \frac{R_3}{1+\beta_2}\right) \| R_4 + R_L\right]} = \frac{159}{0.05\left[(0.03+0.06) \| 10 + 10\right]}$$

$$= 320 \text{ Hz}$$



Example: the CE plus emitter follower amplifier



$$A_m = \frac{R_B}{R_B + (1+\beta_1) r_{E1}} \cdot \frac{\beta_1 R_3}{R_S + R_B \| (1+\beta_1) r_{E1}} \cdot \frac{R_4 \| R_L}{R_4 \| R_L + r_{E2} + R_3/(1+\beta_2)}$$

$K_1 \uparrow$ $\quad$ $K_2 \uparrow$ $\quad$ $K_3 \uparrow$

Exercise

Find the impedances Z_o', Z_i', Z_o, Z_i in factored pole-zero form in the presence of C_1 and C_3

Exercise Solution

$$Z_o' = \frac{A}{\frac{A}{R_L}\Big|_{R_L\to 0}} = R_{om}' \frac{\frac{1}{1+\frac{\omega_5}{s}}}{\frac{1}{1+\frac{\omega_5}{s}\Big|_{R_L\to 0}}}$$

$$= R_{om}' \frac{1+\frac{\omega_5}{s}\Big|_{R_L\to 0}}{1+\frac{\omega_5}{s}}$$

$$Z_o = R_{om} \frac{1+\frac{\omega_5}{s}\Big|_{R_L\to 0}}{1+\frac{\omega_5}{s}\Big|_{R_L\to\infty}} = R_{om}\left(1+\frac{\omega_5}{s}\Big|_{R_L\to 0}\right)$$

($\frac{\omega_5}{s}\Big|_{R_L\to\infty} \to 0$)

$$Z_i' = \frac{R_S A\big|_{R_S\to\infty}}{A}$$

$$= R_{im}' \frac{\frac{1}{1+\frac{\omega_3}{s}\Big|_{R_S\to\infty}}}{\frac{1}{1+\frac{\omega_3}{s}}} = R_{im}'\left(1+\frac{\omega_3}{s}\right)$$

($\frac{1}{1+\frac{\omega_3}{s}\Big|_{R_S\to\infty}} \to 0$)

$$Z_i = R_{im}\left(1+\frac{\omega_3}{s}\Big|_{R_S\to 0}\right)$$

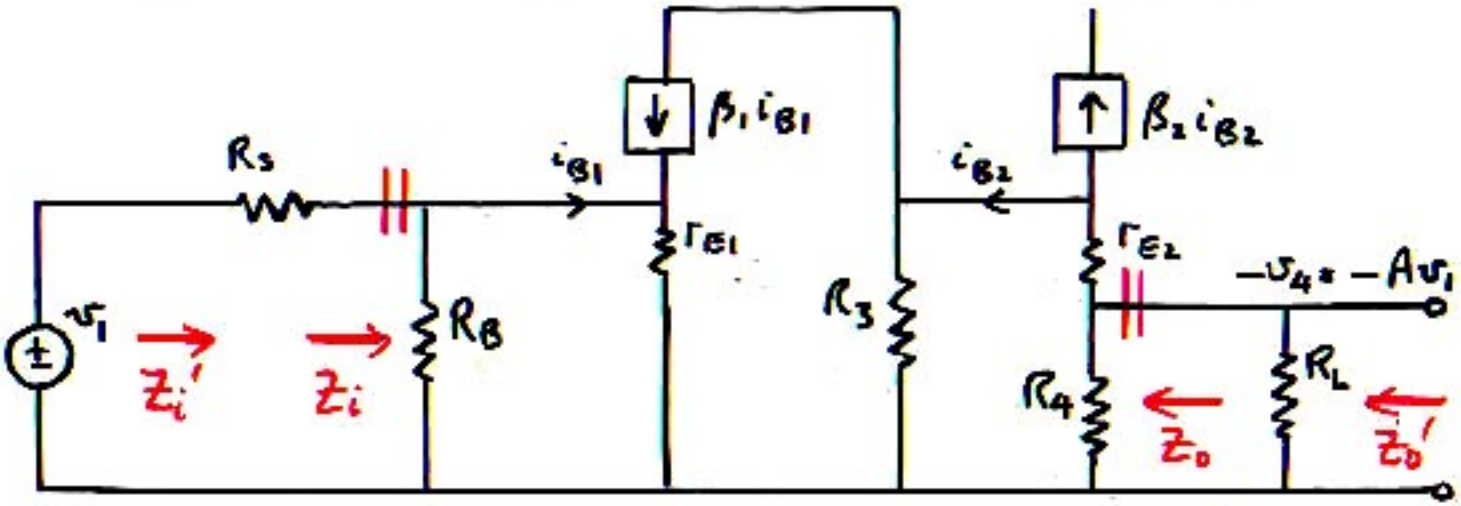
$$\omega_3 \equiv \frac{1}{C_1[R_S + R_B \| (1+\beta_1) r_{E1}]}$$

$$\omega_5 \equiv \frac{1}{C_3\left[\left(r_{E2} + \frac{R_3}{1+\beta_2}\right) \| R_4 + R_L\right]}$$

$$\omega_5\Big|_{R_L\to 0} = \frac{1}{C_3\left[\left(r_{E2} + \frac{R_3}{1+\beta_2}\right) \| R_4\right]}$$

$$\omega_3\Big|_{R_S\to 0} = \frac{1}{C_1[R_B \| (1+\beta_1) r_{E1}]}$$

Example: the CE plus emitter follower amplifier



$$A_m = \frac{R_B}{R_B + (1+\beta_1) r_{E1}} \cdot \frac{\beta_1 R_3}{R_S + R_B \| (1+\beta_1) r_{E1}} \cdot \frac{R_4 \| R_L}{R_4 \| R_L + r_{E2} + R_3/(1+\beta_2)}$$

$K_1 \uparrow$ $\quad$ $K_2 \uparrow$ $\quad$ $K_3 \uparrow$

Exercise

Find the impedances Z_o', Z_i', Z_o, Z_i in factored pole-zero form in the presence of C_1 and C_3