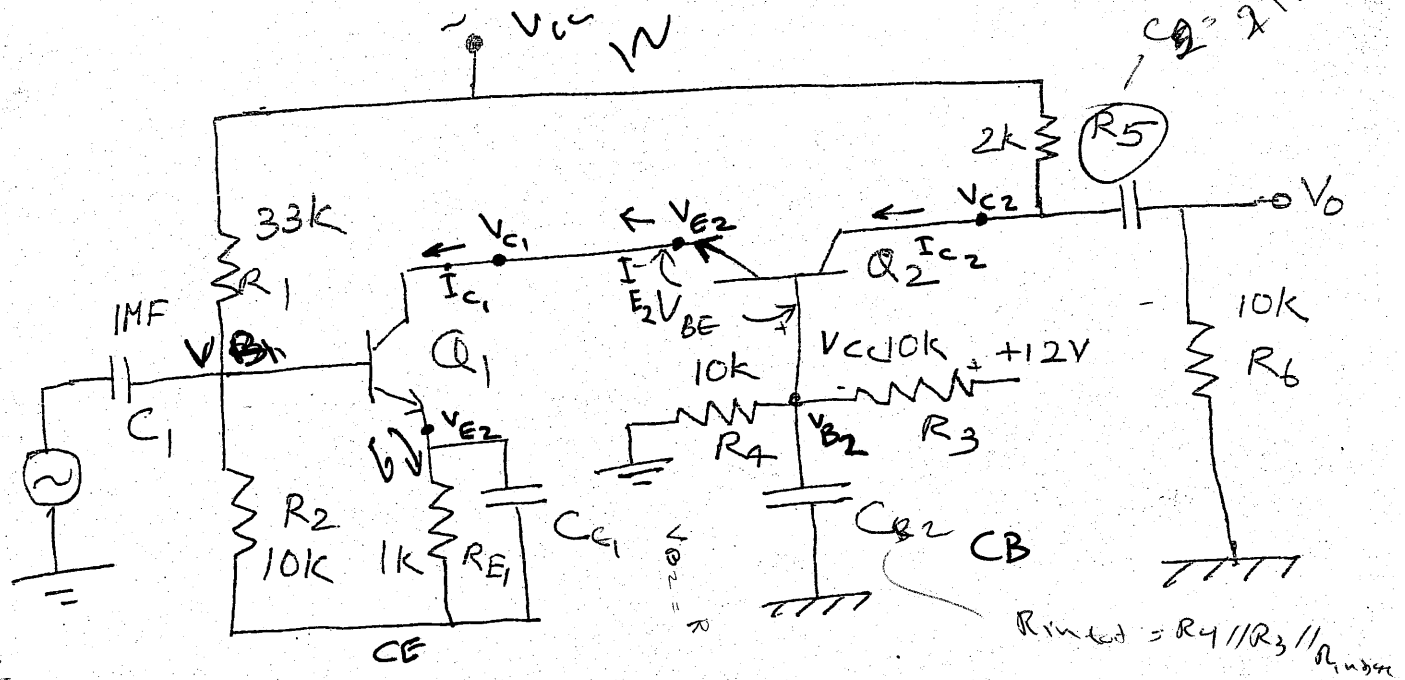
Problem Combination - 1



1 For the above cascode amplifier (CE stage followed by a CB stage), Determine

(i) I_{C_1}, I_{C_2}, V_{C_1}, V_{C_2}

(ii) overall voltage gain

(iii) cut off frequency

Take $\beta = 100$

$C_1 = \frac{1}{2\pi f_c R_{in_c}}$

$R_{in_{base}} = \beta r_e$

$r_e = \frac{25}{I_E}$

Solution

(i)

Step 1 find I_{C_1} and I_{C_2}

$$V_{B_1} = \frac{12 \times R_2}{R_1 + R_2} = \frac{12 \times 10k}{10k + 33k} = 2.8V$$

$$V_{E_1} = V_{B_1} - V_{BE_1} = 2.8 - 0.7 = 2.1V$$

$$I_{C_1} \cong I_{E_1} = \frac{V_{E_1}}{R_{E_1}} = \frac{2.1}{1k} = 2.1\,mA$$

Since emitter of Q_2 is in series with Collector of Q_1, $I_{E_2} = I_{C_1} = 2.1\,mA$

$$I_{E_1} \cong I_{C_2} = 2.1\,mA$$

Step 2 Find V_{C_1} & V_{C_2}

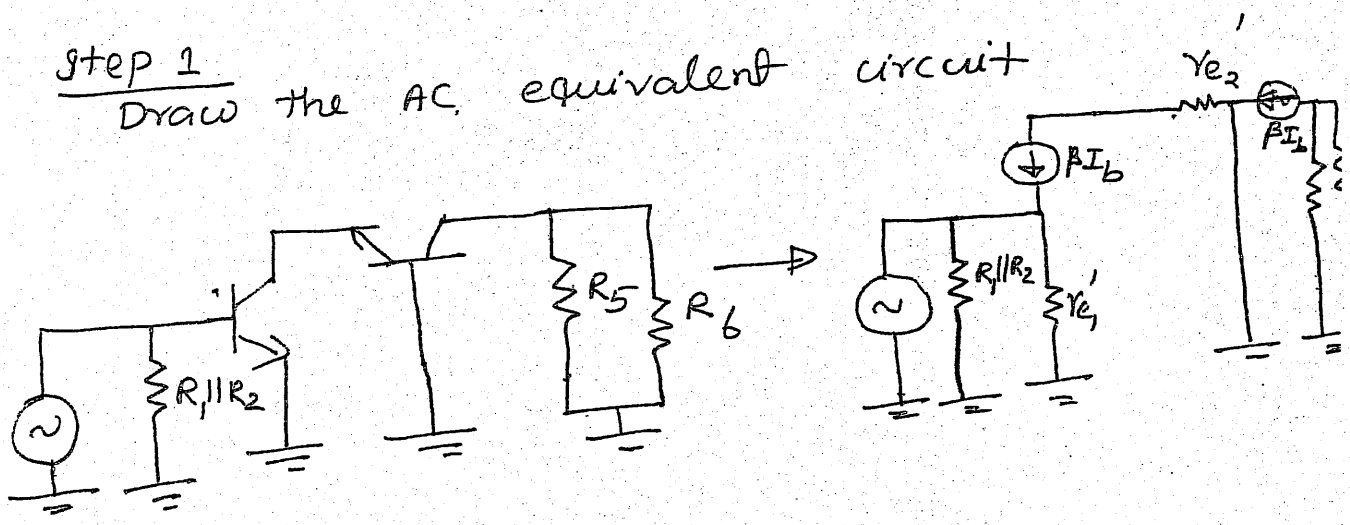
$$V_{B_2} = \frac{12 \times R_4}{R_4 + R_3} = \frac{12 \times 10k}{10k + 10k} = 6V$$

$$V_{C_1} = (V_{E_2}) = V_{B_2} - 0.7 = 6 - 0.7 = 5.3V$$

$$V_{C_2} = V_{CC} - I_{C_2} R_5$$
$$= 12 - 2.1 \times 10^{-3} \times 2 \times 10^{3} = 7.8V$$

(11) To find overall voltage gain, find individual voltage gain and then multiply.

Step 1
Draw the AC equivalent circuit



$$A_{V_1} = \frac{-R_{L_1}'}{r_{e_1}'} \quad \text{——— (1)}$$

R_{L_1}' = Total collector load resistance of $Q_1 = r_{e_2}'$

Since $I_{E_1} = I_{E_2}$, $r_{e_1}' = r_{e_2}' = \frac{25\,mV}{2.1\,mA} = 12\,\Omega$

Substituting r_{e_1}' and r_{e_2}' in (1)

$$A_{V_1} = \frac{-R_{L_1}'}{} = \frac{-R_{L_2}'}{} = \frac{12}{12} = -1$$

$$A_{V_2} = \frac{R_{L_2}'}{r_{e_2}'} = \frac{R_5 \| R_6}{r_{e_2}'} = \frac{2k \| 10k}{12\Omega} = \frac{1.66 \times 10^3}{12} = 138$$

Overall gain $= A_{V_1} \times A_{V_2} = -1 \times 138 = -138$

(iii) Lower cut off frequency $f_{c_L} = \frac{1}{2\pi R_{in} C_1}$

$R_{in(stage1)} = (R_1 \| R_2) \| \beta r_{e_1}'$

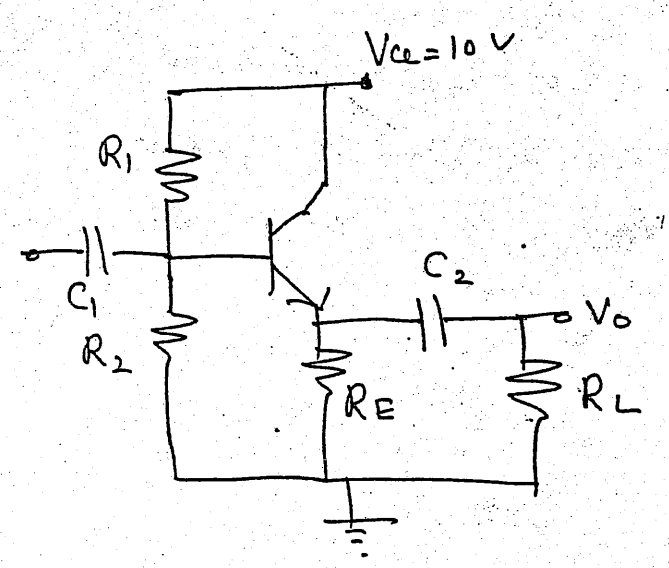
$= (33k \| 10k) \| (100 \times 12)$

$= 7.67k \| 1200$

$= 1.04k$

$\therefore f_{c_L} = \frac{1}{2\pi \times 1.04 \times 10^3 \times 1 \times 10^{-6}} =$

Design a C.C amplifier with $V_{cc} = 10V$. Determine its current gain and input impedance. Given that $\beta = 175$, $R_L = 2.5K$.



$V_{CC} = 10V$

Take $I_C = 2mA$

$V_{CE} = 50\%$ of $V_{CC} = 5V$

$V_{RE} = V_{CC} - V_{CE} = 5V$

$\therefore R_E = \frac{V_{RE}}{I_E} = \frac{V_{RE}}{I_C} = \frac{5}{2mA} = 2.5K$

$I_B = \frac{I_C}{\beta} = \frac{2mA}{175} = 0.0114mA$

Take $I_{R_1} \cong I_{R_2} = 10 I_B = 0.114mA$

$V_B = V_{R_2} = V_{RE} + V_{BE} = 5 + 0.7 = 5.7V$

$\therefore R_2 = \frac{V_{R_2}}{I_{R_2}} = \frac{5.7}{0.114mA} = 50K$.

$R_1 = \frac{V_{R_1}}{I_{R_2}} = \frac{V_{CC} - V_{R_2}}{I_{R_2}} = \frac{10 - 5.7}{0.114} = 38K$.

$r_e' = \frac{25mV}{I_E} = \frac{25}{2} = 12.5\Omega$

$A_V = \frac{R_L'}{r_e' + R_L'} = 0.99$

$R_L' = R_E \| R_L = 2.5K \| 2.5K = 1.25K$.

$R_{in(base)} = \beta (r_e' + R_L') = 175(12.5 + 1.25K) = 219K$

$R_{in} = R_1 \| R_2 \| R_{in(base)} = 38k \| 50k \| 219K = 21.6 \| 219 = 19.6K$.

$I_e = \frac{V_e}{R_L'} = \frac{A_V . V_{in}}{R_L'} = \frac{.99 . V_{in}}{1.25k} = 0.8 \times 10^{-3} V_{in}$

$I_{in} = \frac{V_{in}}{R_{in}} = \frac{V_{in}}{19.6K} = 0.05 \times 10^{-3} V_{in}$

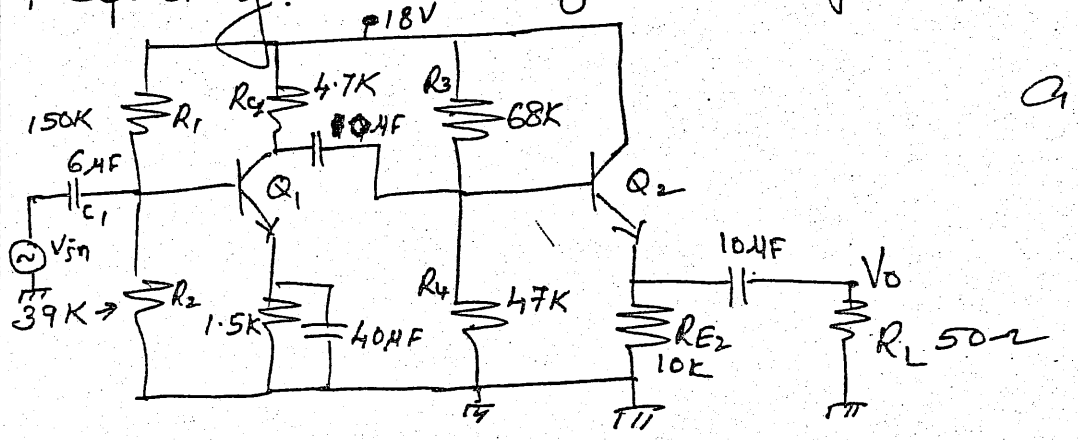
$A_i = \frac{I_e}{I_{in}} = \frac{.8 \times 10^{-3} V_{in}}{.05 \times 10^{-3} V_{in}} = 16$

Figure shows an amplifier consisting of a C.E stage driving an emitter follower stage. The transistors have the following parameters.

$Q_1 \rightarrow \gamma_{e_1}' = 15\Omega \quad \beta_1 = 180$

$Q_2 - \gamma_{e_2}' = 40\Omega \quad \beta_2 = 100$

Find the voltage gain and the approximate value of the lower cut-off frequency caused by the capacitor C_1.



Q_1 & Q_2 are equal at

$R_{in_1} = R_1 \| R_2 \| \beta_1 r_{e_1}' = 150K \| 39K \| (180 \times 15) = 2.48K\Omega$

Load of stage 1 $= R_{L_1}' = R_{C_1} \| R_{in_2} = 4.7K \| R_{in_2}$

$R_{in_2} = R_3 \| R_4 \| \beta(r_{e_2}' + R_{L_2}')$ $\quad R_{L_2}' = R_{E_2} \| R_L$

$= 10K \| 50 = 50\Omega$

$= 68K \| 47K \| 100(40+50)$

$= \underline{6.8K}$ $\quad \therefore R_{L_1}' = 4.7K \| 6.8K = \underline{2.8K}$

out

C CE

E CB

Capacitor
open in DC

For Resistors use DC Anal.

Capacititans AC.