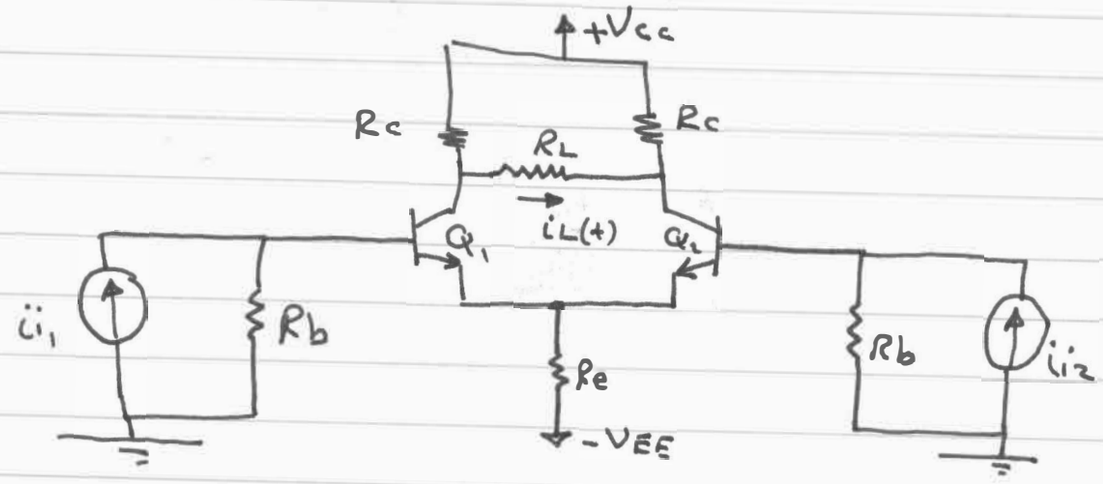
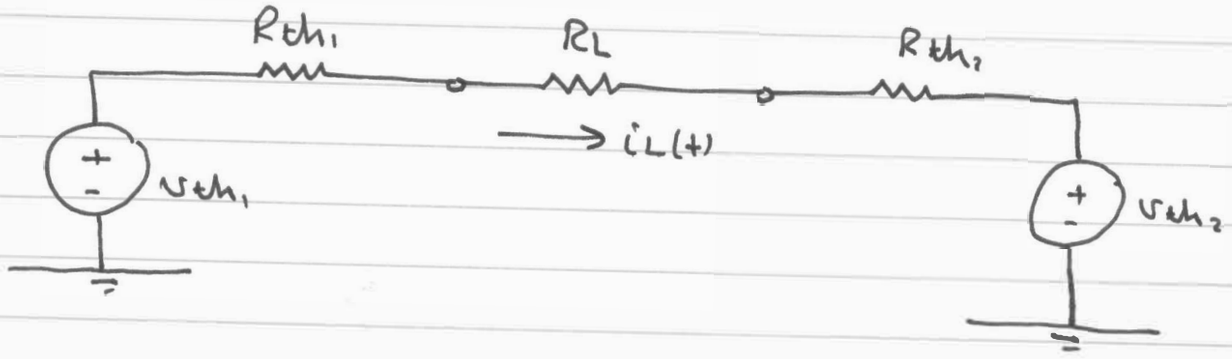
Homework Solution

7.1-4



Using Thevenin's equivalent circuits



$$i_L(t) = \frac{v_{th1} - v_{th2}}{R_{th1} + R_{th2} + R_L}$$

$$v_{th1} = \frac{R_c\, v_d}{2\left(h_{ib} + \frac{R_b}{h_{fe}+1}\right)} - \frac{R_c\, v_c}{2R_e + h_{ib} + \frac{R_b}{h_{fe}+1}}$$

$$v_{th2} = \frac{-R_c\, v_d}{2\left(h_{ib} + \frac{R_b}{h_{fe}+1}\right)} - \frac{R_c\, v_c}{2R_e + h_{ib} + \frac{R_b}{h_{fe}+1}}$$

$$R_{th1} = R_{th2} = R_c$$

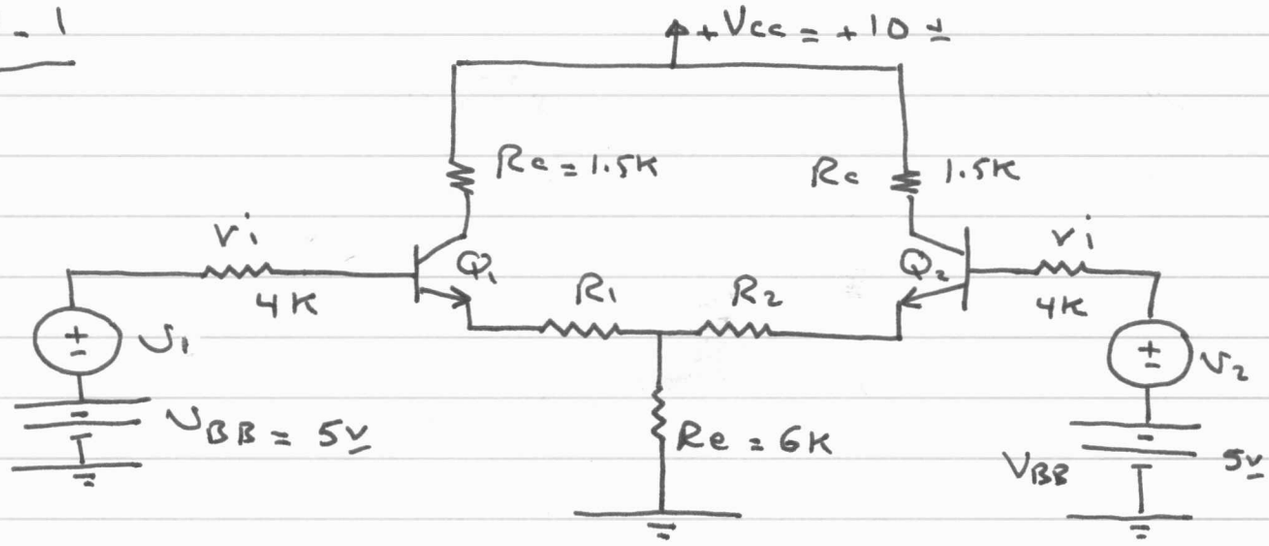
$$v_d = R_b i_{i2} - R_b i_{i1}$$

$$v_c = \frac{R_b i_{i2} + R_b i_{i1}}{2}$$

$$\therefore \quad i_L(t) = \frac{R_c R_b (i_{i2} - i_{i1})}{(2R_c + R_L)\left(h_{ib} + \frac{R_b}{h_{fe}+1}\right)}$$

$$\therefore \quad i_L(t) = K (i_{i2} - i_{i1})$$

7.4-1



$h_{fe_1} = 100$; $h_{fe_2} = 200$; $R_x = R_1 + R_2 = 100\,\Omega$

$$V_{BB} + v_i I_{B_1} + V_{BE_1} + R_1 I_{E_1} = V_{BB} + v_i I_{B_2} + V_{BE_2} + R_2 I_{E_2}$$

$$v_i I_{B_1} + R_1 I_{E_1} = v_i I_{B_2} + R_2 I_{E_2}$$

To make $I_{E_1} = I_{E_2}$

$$\frac{v_i}{h_{fe_1}+1} + R_1 = \frac{v_i}{h_{fe_2}+1} + R_2$$

$$\therefore \quad R_2 - R_1 = \frac{v_i}{h_{fe_1}+1} - \frac{v_i}{h_{fe_2}+1}$$

and $R_1 + R_2 = R_x$ given

Solving

$$R_1 = \frac{R_x}{2} - \frac{v_i}{2}\left(\frac{1}{h_{fe_1}+1} - \frac{1}{h_{fe_2}+1}\right)$$

$$R_2 = \frac{R_x}{2} + \frac{v_i}{2}\left(\frac{1}{h_{fe_1}+1} - \frac{1}{h_{fe_2}+1}\right)$$

$\therefore R_1 = 40\,\Omega$

$R_2 = 60\,\Omega$

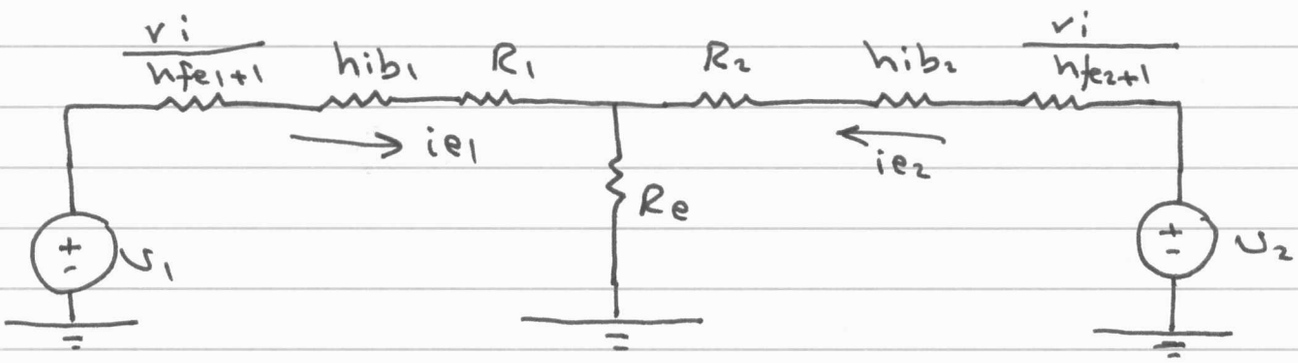
To Find $I_{E_1} = I_{E_2}$

$$V_{BB} = r_i I_{B_1} + V_{BE_1} + R_1 I_{E_1} + 2R_e I_{E_1}$$

$\therefore I_{E_1} = I_{E_2} = 0.356\ mA$

$$h_{ib_1} = h_{ib_2} = \frac{V_T}{I_{E_1}} = 70\,\Omega$$

To Find Ad, Ac, and CMRR



1) To Find $A_d = \left.\frac{V_o}{V_d}\right|_{V_c = 0}$

$$V_o \cong -i_{e_2} R_c$$

$$i_{e_2} = \frac{V_d}{2\left(R_2 + h_{ib_2} + \frac{v_i}{h_{fe_2+1}}\right)}$$

$\therefore A_d = -5$

2) To find $A_c = \left.\frac{v_o}{v_c}\right|_{v_d=0}$

$$v_o \simeq -i_{e_1} R_c$$

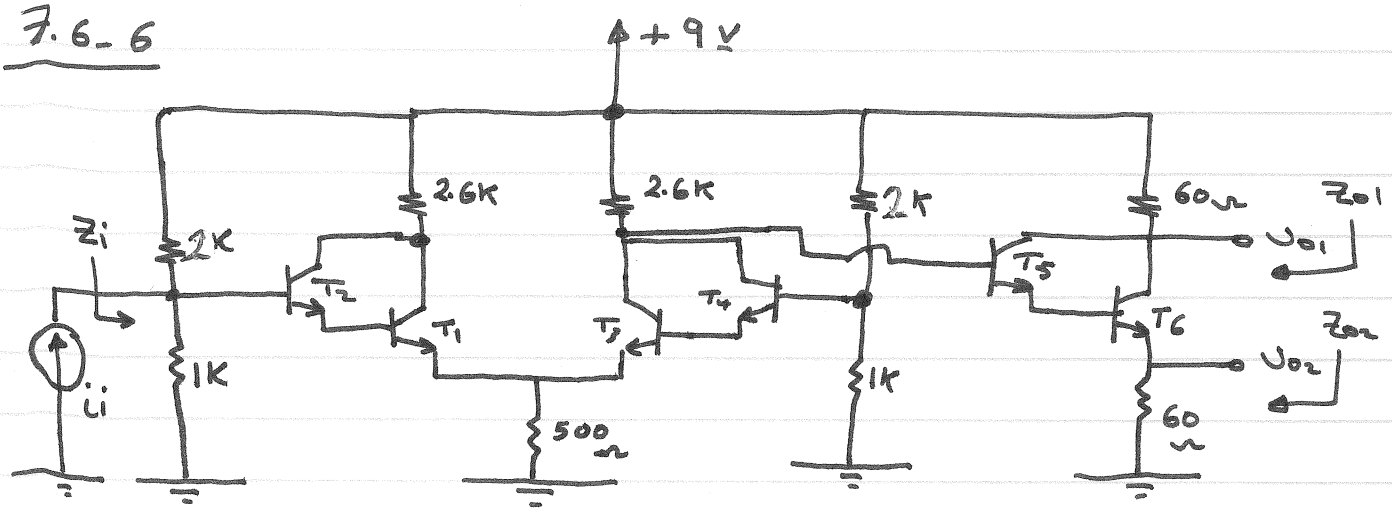
$$i_{e_2} = \frac{v_c}{2R_e + R_2 + h_{ib_2} + \frac{v_i}{h_{fe_2+1}}}$$

$$\therefore A_c = -0.123$$

$$CMRR = \left| \frac{A_d}{A_c} \right|$$

$$CMRR = 40.7$$

7.6_6



DC Analysis

$$R_{TH} = 1K \| 2K = 0.667K$$

$$V_{TH} = \frac{1K}{2K+1K}(9) = 3\ V$$

$$V_{TH} = R_{TH} I_{B2} + V_{BE2} + V_{BE1} + (0.5K)(2I_{E1})$$

$$I_{E1} = (\beta+1)(\beta+1) I_{B2}$$

$$\therefore I_{E1} = 1.6\ mA$$

$$I_{E2} \cong 0.016\ mA$$

$$h_{ie2} = \frac{\beta V_T}{I_{E2}} = 162.5K$$

$$h_{ieD_{1,2}} = h_{ieD_{3,4}} = 325K$$

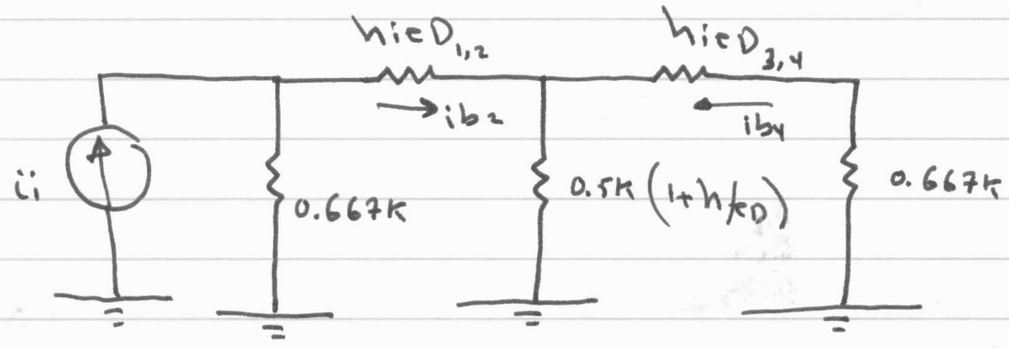
$$9 = 2.6K\left(I_{C3} + I_{C4} + I_{B5}\right) + V_{BE5} + V_{BE6} + 60_\Omega I_{E6}$$

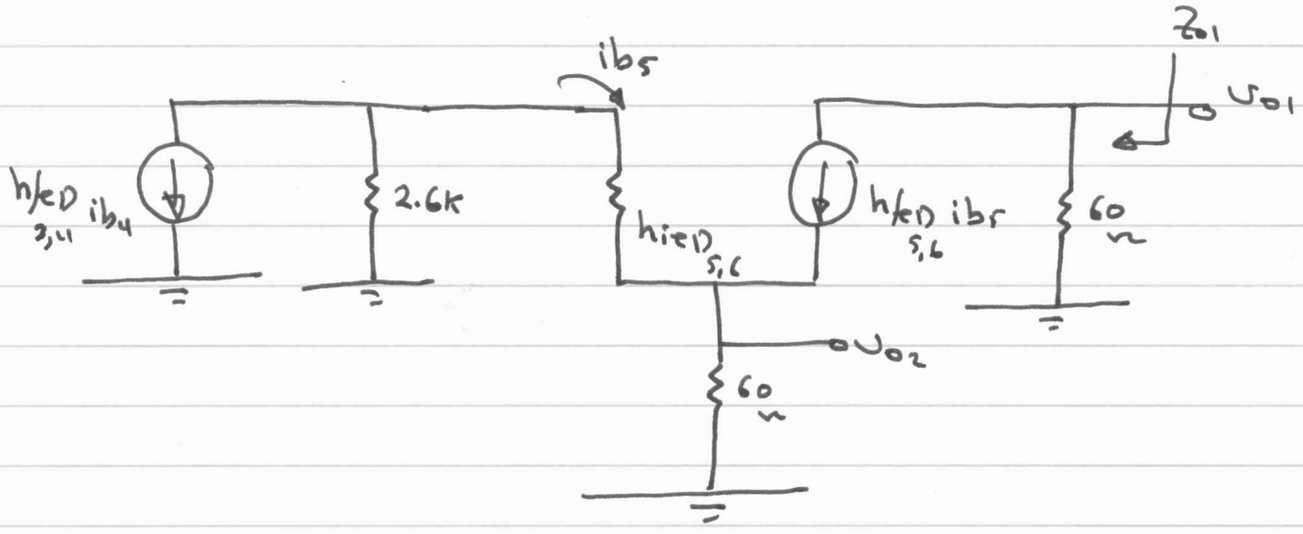
$$\therefore I_{E6} \cong 56.4\ mA$$

$$\therefore I_{E5} \cong 0.564\ mA$$

$h_{ie_{5,6}} = 9.22\,k$

ac small Signal equivalent CKT





Differential Mode Analysis

$$v_{o1} = -h_{fe_{5,6}} i_{b5} (60\Omega)$$

$$i_{b5} = -h_{fe_{3,4}} i_{b4} \frac{2.6k}{2.6k + h_{ie_{5,6}} + 60\Omega (1+h_{fe_{5,6}})}$$

$$i_{b4} = -i_{b2}$$

$$i_{b2} = i_i \frac{0.667k}{0.667k + h_{ie_{1,2}} + h_{ie_{3,4}} + 0.667k}$$

$$\therefore \frac{V_{o1}}{i_i} = -26.1 \times 10^3$$

$$Z_i = 0.667k \parallel \left(h_{ie}D_{1,2} + h_{ie}D_{3,4} + 0.667k \right)$$

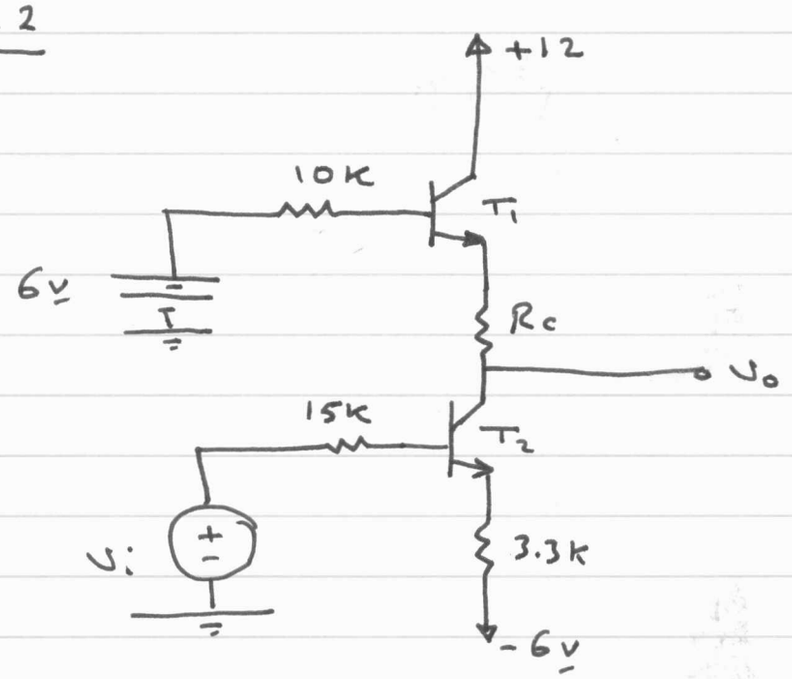
$$Z_i \approx 0.667k$$

$$Z_{o1} = 60\,\Omega$$

$$Z_{o2} = 0.06k \parallel \left(\frac{2.6k + h_{ie}D_{5,6}}{h_{fe}D_{5,6}} \right) \approx 1\,\Omega$$

$$\frac{V_{o2}}{i_i} \approx -26.1 \times 10^3$$

7.7-2



$$(15K)\, I_{B_2} + 0.7 + (3.3K)\, I_{E_2} - 6 = 0$$

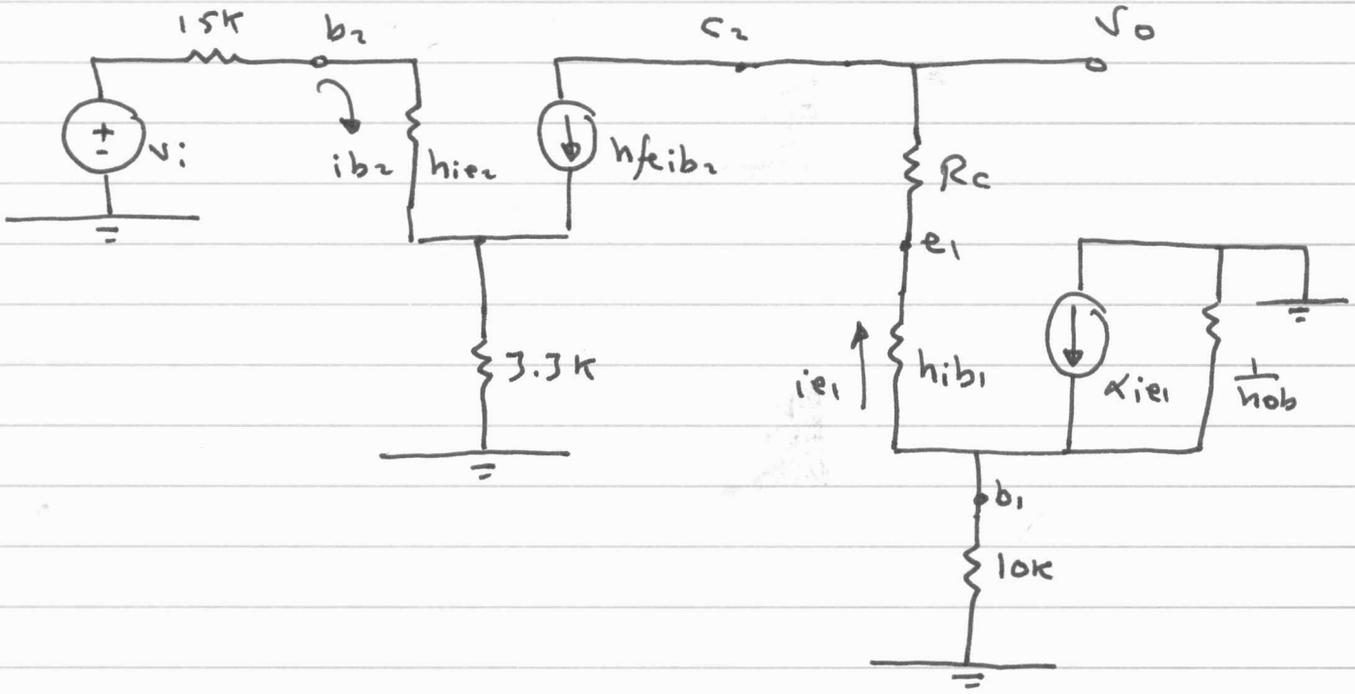
$$\therefore I_{E_2} = 1.57\ mA$$

$$6 = (10K)\, I_{B_1} + 0.7 + R_c I_{E_1} + 0$$

$$I_{E_1} = I_{C_2} \cong I_{E_2} = 1.57\ mA$$

$$\therefore R_c = 3.326\ K$$

ac small signal equivalent ckt



$$V_o = -i_{e_1}\left(R_c + h_{ib_1} + \frac{10K \parallel \frac{1}{h_{ob}}}{1+h_{fe}}\right)$$

$$i_{e_1} = h_{fe} i_{b_2}$$

$$i_{b_2} = \frac{V_i}{1.5K + h_{ie_2} + 3.3K(1+h_{fe})}$$

$$\therefore A_V \simeq -0.99$$