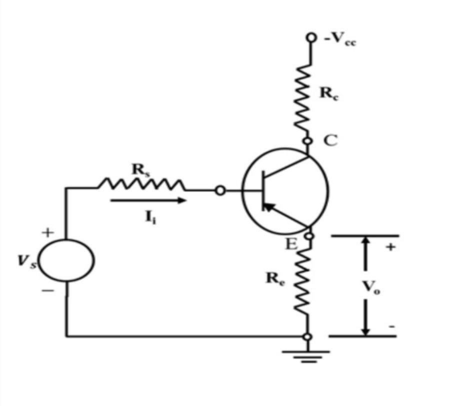
1. For the circuit shown, find the voltage gain, input impedance and output impedance (include the source resistance Rs within the input impedance of the transistor)

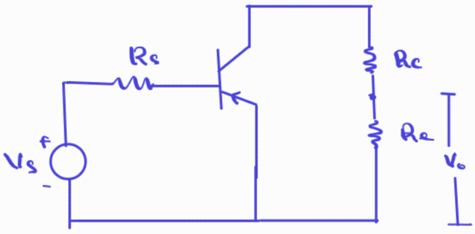


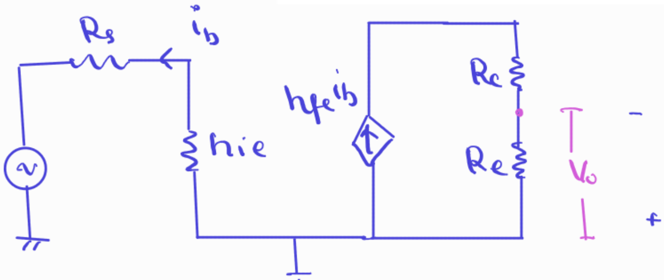
Feedback- method:

$V_E = V_o \qquad V_B = V_s - I_1 R_s$

$V_B - V_E = V_B - I_1 R_s - V_o \qquad \boxed{\beta = 1}$

$\Rightarrow$ feedback - circuit





$$A_{vf} = \frac{A_v}{1 + \beta A_v}$$

$$= \frac{\dfrac{h_{fe} R_e}{R_s + h_{ie}}}{1 + \beta \dfrac{h_{fe} R_e}{R_s + h_{ie}}}$$

$$= \frac{h_{fe} R_e}{R_s + h_{ie} + \beta h_{fe} R_e}$$

$$V_o = - h_{fe} i_b R_e$$

$$= + h_{fe} \frac{V_s}{R_s + h_{ie}} R_e$$

$$A_v = \frac{V_o}{V_s} = + \frac{h_{fe} R_e}{R_s + h_{ie}}$$

$$D = 1 + \beta A_v = 1 + A_v$$

$$= \frac{R_s + h_{ie} + h_{fe} R_e}{R_s + h_{ie}}$$

$$Z_{in} = R_s + h_{ie}$$

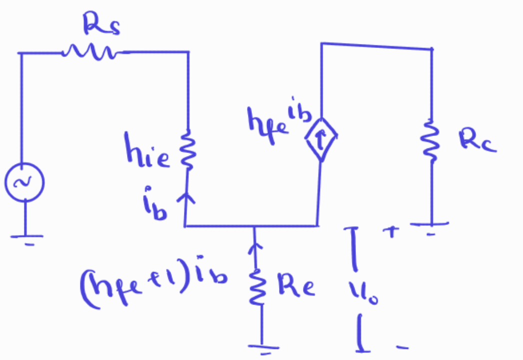
$$Z_o' = R_e$$

$$Z_{if} = (R_s + h_{ie}) D$$

$$R_{of}' = \frac{R_e (R_s + h_{ie})}{R_s + h_{ie} + h_{fe} R_e}$$

$$R_{of} = \frac{R_s + h_{ie}}{h_{fe}}$$

Without feedback.



$$V_s + (h_{ie} + R_s) i_b + R_e (h_{fe} + 1) i_b = 0$$

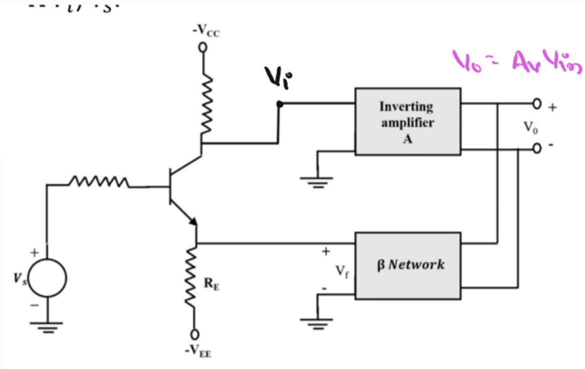
$$i_b = \frac{- V_s}{h_{ie} + R_s + R_e (h_{fe} + 1)}$$

$$Z_{in} = h_{ie} + R_s + R_e (h_{fe} + 1)$$

$$V_o = - (h_{fe} + 1) i_b R_e$$

$$R_o = R_e \,||\, (R_s + h_{ie}) \qquad \frac{V_o}{V_s} = \frac{(h_{fe} + 1) R_e}{h_{ie} + R_s + R_e (h_{fe} + 1)}$$

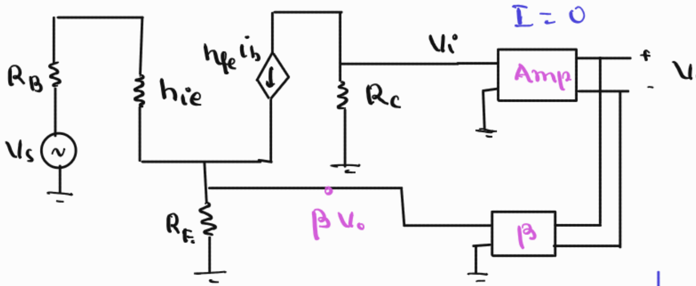
2. For the circuit shown, find the ac voltage V_i as a function of V_s and V_f, Assume that the inverting-amplifier input resistance is infinite, that $A = Av = -1{,}000, \beta = V_f/V_0 = \frac{1}{100}, R_S = R_C = R_e = 1K, h_{ie} = 1K, h_{re} = h_{oe} = 0, and\ h_{fe} = 100$. (b) Find $A_{vf} = V_o/V_s = A\,V_i/V_s$.



$V_i = V_i(V_s, V_f)$

$R_i(\text{inv.}) = \infty$

$A_v = -1000 \qquad \beta = \frac{1}{100}$



$V_o = A_v V_i$

$V_i = -h_{fe}\, i_b R_c$

$V_i \left(1 - \frac{h_{fe} R_c \beta A_v}{R_B + h_{ie}}\right) = -\frac{h_{fe} R_c}{R_B + h_{ie}} V_s \quad \Bigg| \quad V_i = \frac{-h_{fe} R_c \left(V_s - \beta A_v V_i\right)}{R_B + h_{ie}}$

$$V_i = \frac{-h_{fe} R_c V_s}{1 - \frac{h_{fe} R_c \beta A_v}{R_B + h_{ie}}}$$

$$\frac{V_o}{A} = -\frac{h_{fe} R_c}{R_B + h_{ie}} \left(V_s - \beta V_o\right)$$

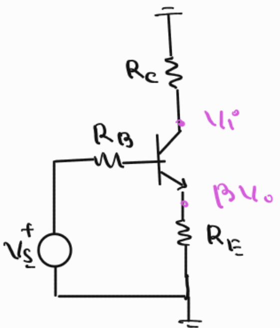
$$V_o \left(\frac{1}{A} - \frac{h_{fe} R_c}{R_B + h_{ie}} \beta\right) = -\frac{h_{fe} R_c}{R_B + h_{ie}} V_s$$

$$A_v = \frac{V_o}{V_s} = -\frac{h_{fe} R_c}{R_B + h_{ie}} \cdot \frac{1}{\frac{1}{A} - \frac{h_{fe} R_c}{R_B + h_{ie}} \beta}$$

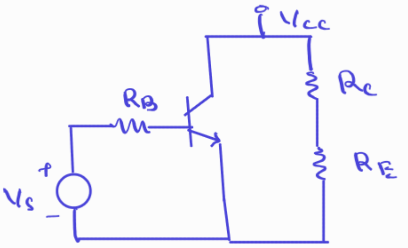
Method-2

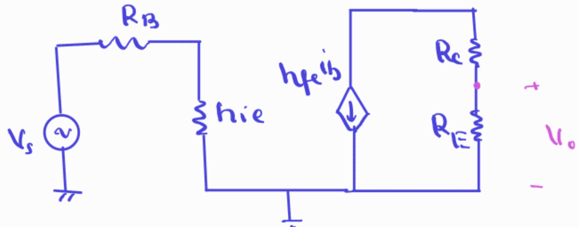
$V_s - i_B R_B - V_{BE} - \beta V_o = 0$

$V_{BE} = \underline{V_s - i_B R_B} - \beta V_o$

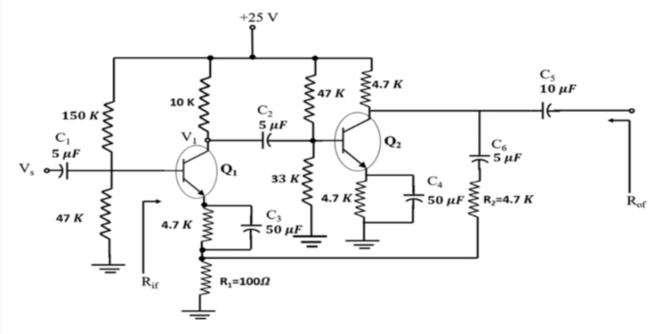


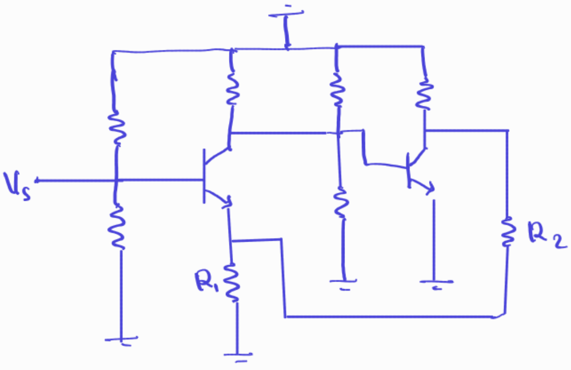
$V_o = A V_i$

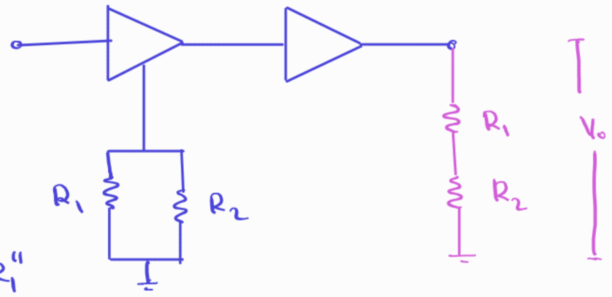




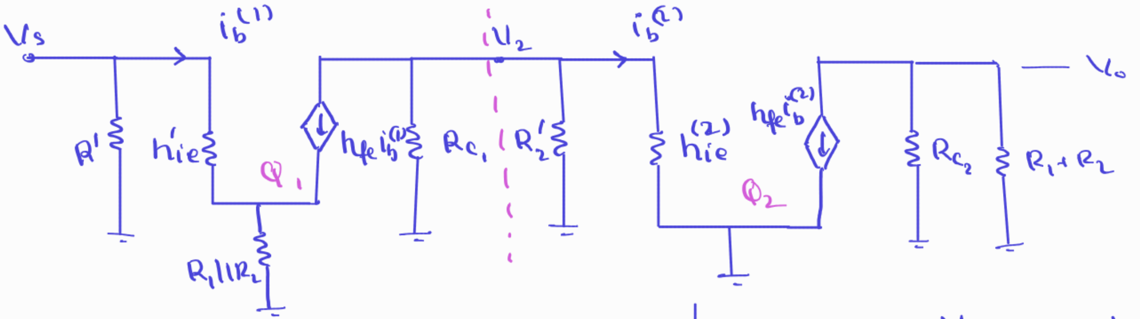
3. For the circuit shown below find the voltage gain, input impedance and output impedance (to find feedback factor β, assume current gain of the second amplifier is very large, so that current through 4.7k resistance in the emitter of Q1 is negligible as compared to current through feedback network resistance 4.7 k which is connected 5 microfarad capacitor in series) (Assume R_s=0, $h_{ie} = 1.1k$, $h_{re} = h_{oe} = 0$)







$R' = R_1' \,||\, R_2''$ $\qquad$ $R'' = R_2'' \,||\, R_1''$



$$A_{v_1}(Q_1) = \frac{V_2}{V_s} = \frac{-h_{fe} i_b R_{C_1}}{V_s} \qquad \Bigg| \qquad \frac{V_o}{R_1+R_2} + \frac{V_o}{R_{C_2}} + h_{fe} i_b^{(2)} = 0$$

$$= \frac{-h_{fe} V_s \quad R_{C_1}}{h_{ie}' + (R_1 || R_2)(h_{fe}+1)} \cdot \frac{1}{V_s} = \frac{-h_{fe} R_{C_1}}{h_{ie}' + (R_1 || R_2)(1+h_{fe})}$$

$$A_{v_2}(Q_2) = \frac{-h_{fe} i_b^{(2)} R_L^{(2)}}{V_2} \qquad R_L^{(2)} = R_{C_2} \,||\, (R_1+R_2)$$

$$= \frac{-h_{fe} R_L^{(2)}}{h_{ie}^{(2)}}$$

$$A_v = A_{v_1} A_{v_2} = \frac{h_{fe} R_{C_1}}{h_{ie}^{(1)} + (R_1 || R_2)(1+h_{fe})} \times \frac{h_{fe} R_L^{(2)}}{h_{ie}^{(2)}}$$

$$A_{vf} = \frac{A_v}{1+\beta A_v}$$

$$Z_{in} = \frac{V_s}{i_b} = h_{ie} + (R_1 || R_2)(h_{fe}+1)$$

$$Z_{if} = Z_{in}(1+\beta A_v)$$

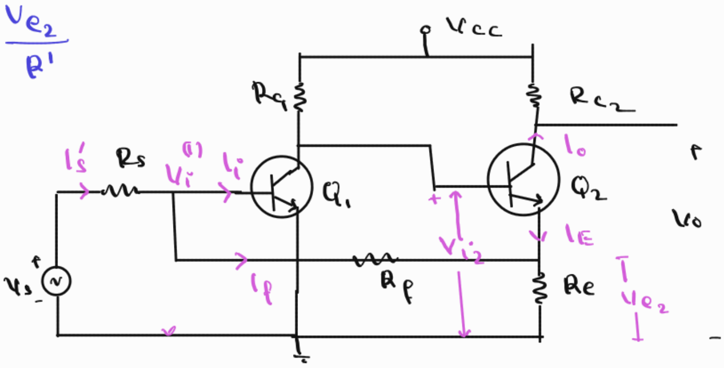
$$Z_o = (R_1+R_2) \,||\, R_{C_2} \qquad Z_{of} = \frac{Z_o}{1+\beta A_v}$$

4. For a general amplifier circuit, find out the current gain, input impedance and output impedance when input is a current source and feedback is a current feedback (I,e current shunt feedback circuit).

$$I_f = \frac{V_i^{(1)} - V_{e_2}}{R_f} \simeq -\frac{V_{e_2}}{R'}$$

$$V_i^{(1)} << V_{e_2}$$

current- shunt



for Q_2 : $I_c \simeq I_E$

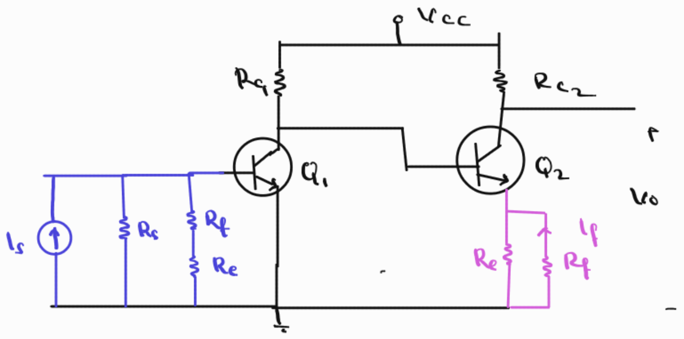
$$V_{e_2} = (I_f - I_o) R_E$$

$$I_f = (I_o - I_f)\frac{R_E}{R_f}$$

$$\Rightarrow \left(1 + \frac{R_E}{R_f}\right) I_f = I_o \frac{R_E}{R_f}$$

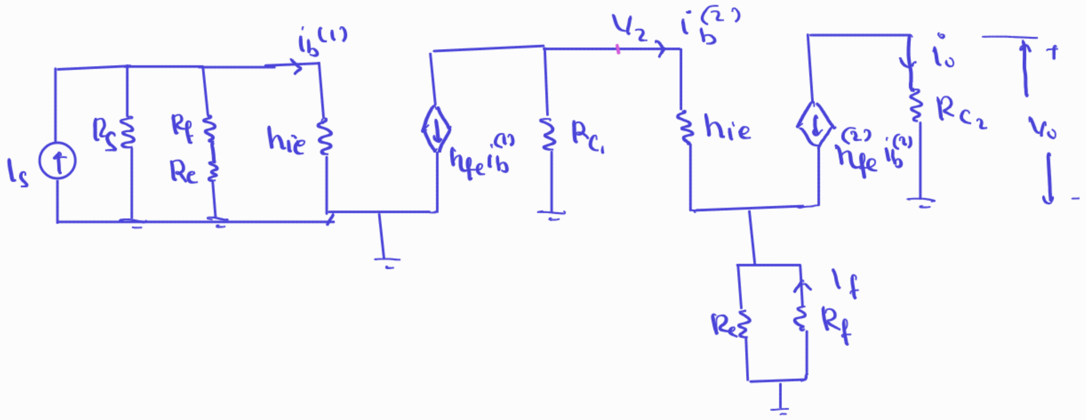
$$\Rightarrow I_f = \frac{R_E}{R_E + R_f} I_o \qquad \beta = \frac{R_E}{R_E + R_f}$$

circuit without feedback



$$Z_{in} = R_s \,||\, (R_f + R_e) \,||\, h_{ie}$$

$$Z_{if} = \frac{R_s \,||\, (R_f + R_e) \,||\, h_{ie}}{1 + A_i \beta}$$



$$A_i = \frac{I_o}{I_s} = \frac{i_o}{i_b^{(2)}} \cdot \frac{i_b^{(2)}}{i_b^{(1)}} \cdot \frac{i_b^{(1)}}{i_s}$$

$$A_i = \frac{i_o}{i_s} = \frac{-h_{fe}^{(2)}}{\cancel{i_b^{(1)}}\ \cancel{i_s}} \cdot \frac{-h_{fe}^{(1)}\ \cancel{i_b^{(1)}}\ R_{C_1}}{R_{C_1} + h_{ie}^{(2)} + (R_e + R_f)(h_{fe}^{(2)}+1)} \cdot \frac{\cancel{i_s}\ (R_s \parallel (R_f + R_e))}{h_{ie}^{(1)} + (R_s \parallel (R_f + R_e))}$$

$$= -h_{fe}^{(2)} \cdot \frac{-h_{fe}^{(1)}\ R_{e_1}}{R_{e_1} + h_{ie}^{(2)} + (R_e + R_f)(h_{fe}^{(2)} + 1)} \cdot \frac{R_s \parallel (R_f + R_e)}{h_{ie}^{(1)} + (R_s \parallel (R_f + R_e))}$$

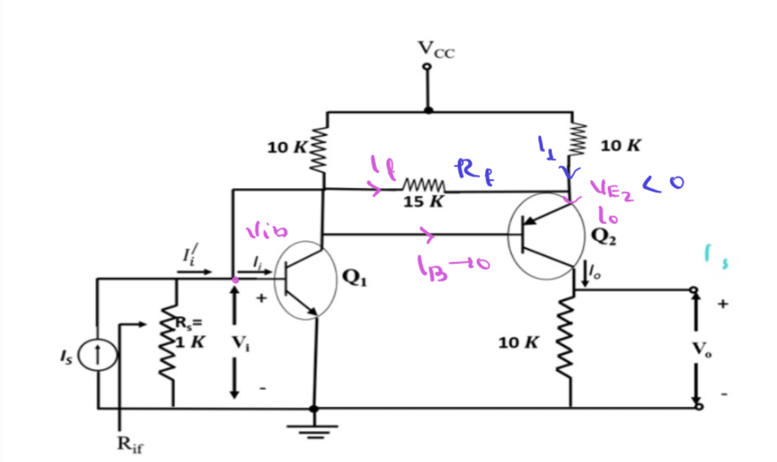
$$A_{if} = \frac{A_i}{1 + \beta A_i}$$

$$A_{vf} = \frac{V_o}{V_s} = \frac{i_o R_{C_2}}{i_s\ R_s} = A_{if}\ \frac{R_{C_2}}{R_s}$$

$$R_{of} = R_{C_2}(1 + \beta A_i)$$

5. In the two-stage feedback amplifier shown, the transistors are identical and have the following parameters: $h_{fe} = 50, h_{ie} = 2\,K, h_{re} = 0, and\ h_{oe} = 0$ calculate

(a) $A_{If} = \frac{I_o}{I_S}$, (b) $R_{if} = \frac{V_i}{I_S}$, (c) $A_{if}^{/} = \frac{I_o}{I_i^{/}}$, (d) $A_{vf} = \frac{V_o}{V_S}$, where $V_S = I_s R_S$.



$$I_f = \frac{V_{ib} - V_{E2}}{R_f}$$

$$V_{ib} << V_{E2}$$

$$I_f = -\frac{V_{E2}}{R_f}$$

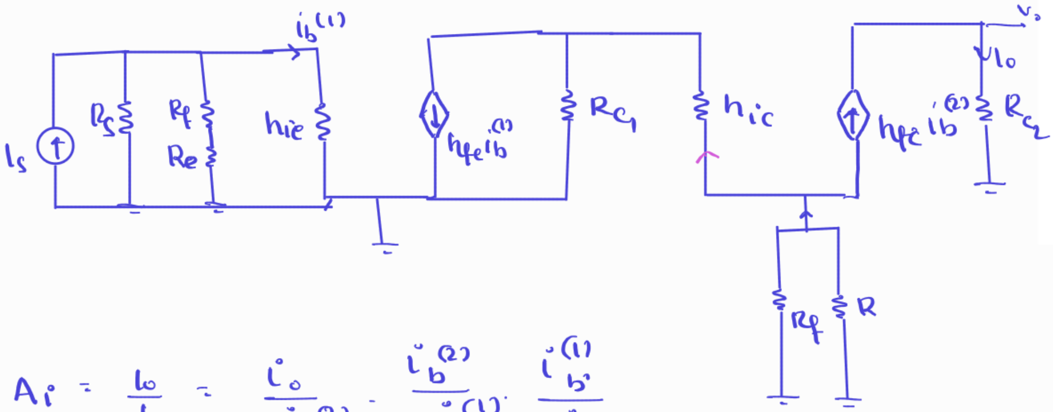
$$V_{E2} = -I_1 R_{E2}$$

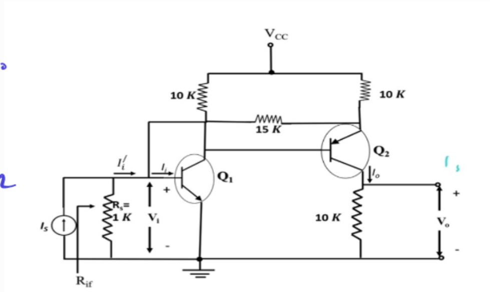
$$= -(I_o - I_f) R_{E2}$$

$$I_f = \frac{(I_o - I_f) R_{E2}}{R_f}$$

$$\frac{R_f + R_{E2}}{R_f} I_f = I_o \frac{R_{E2}}{R_f}$$

$$\Rightarrow I_f = I_o \frac{R_{E2}}{R_f + R_{E2}} \qquad \beta = \frac{R_{E2}}{R_f + R_{E2}}$$





$$A_i = \frac{I_o}{I_s} = \frac{i_o}{i_b^{(2)}} \cdot \frac{i_b^{(2)}}{i_b^{(1)}} \cdot \frac{i_b^{(1)}}{i_s}$$

$$Z_{in}^{(2)} = h_{ic} + (h_{fc}+1)(R_f \| R)$$

$$= \frac{h_{fc}}{\cancel{i_b^{(1)}}} \; \frac{h_{fe} \cancel{i_b^{(1)}} R_{c1}}{R_{c1} + Z_{in}^{(2)}} \; \frac{\cancel{i_s}\left(R_s \| (R_f + R_e)\right)}{\left(R_s \| (R_f + R_e)\right) + h_{ie}} \cdot \frac{1}{\cancel{i_s}}$$

$$A_i = h_{fc} \frac{h_{fe} R_{c1}}{R_{c1} + Z_{in}^{(2)}} \; \frac{R_s \| (R_f + R_e)}{(R_s \| R_f + R_e) + h_{ie}}$$

$$A_{if} = \frac{A_i}{1 + \beta A_i}$$

$$Z_{in} = R_s \,||\, (R_f + R_e) \,||\, h_{ie}$$

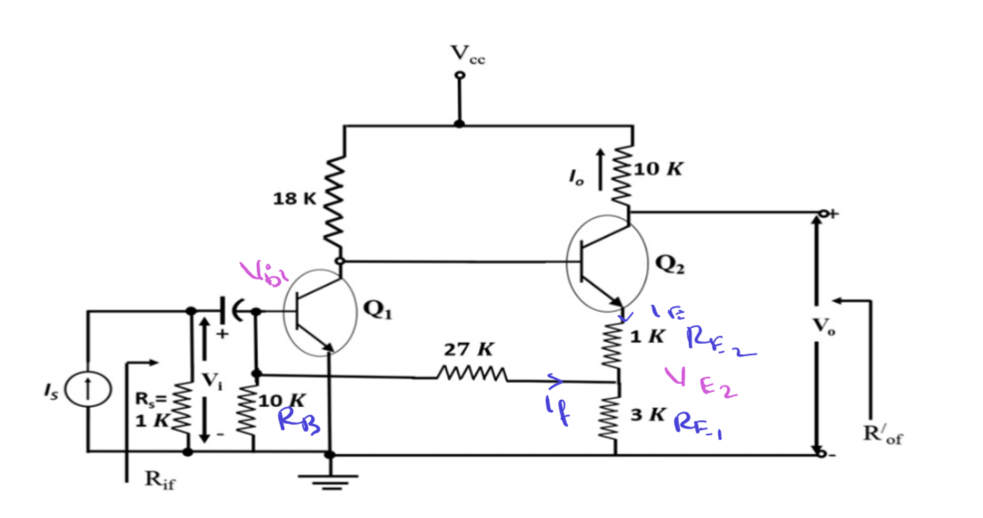
$$Z_{if} = \frac{Z_{in}}{1 + A_i \beta}$$

$$A_i' = h_{fe} \frac{h_{fe} R_{c1}}{R_{c1} + Z_{in}^{Q1}}$$

$$A_{vf} = \frac{V_o}{V_s} = \frac{I_o R_o}{I_s R_s} = A_{if} \frac{R_o}{R_s}$$

6. For the circuit shown (and with the h parameter values given in Prob. 4) find (a) $A_{If} = \frac{I_o}{I_S}$, (b) R_{if} ,(c) $A_{vf} \equiv \frac{V_o}{V_s}$ where $I_S \equiv \frac{V_S}{R_S}$, (d) $A'_{vf} \equiv \frac{V_o}{V_i}$, (e)$R'_{of}$

Assume: To find the value of feedback factor β, assume that $V_i \ll V_{e2}$(voltage at the emitter of Q2) and $I_{e2} \approx I_{c2}$



$$I_f = \frac{V_{b1} - V_{E2}}{R_f}$$

$$I_f = -\frac{V_{E2}}{R_f}$$

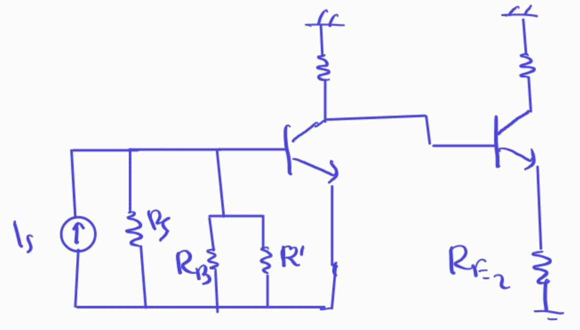
$$= \frac{-(I_f - I_o) R_{E1}}{R_f}$$

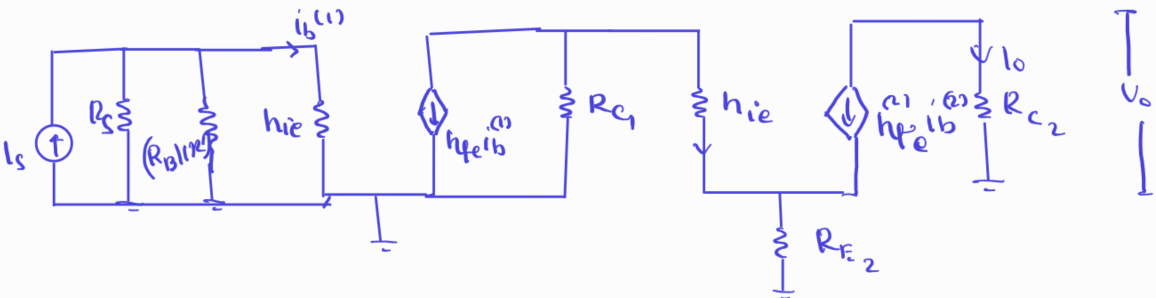
$$\frac{R_f + R_{E1}}{\cancel{R_f}} I_f = \frac{I_o R_{E1}}{\cancel{R_f}}$$

$$\Rightarrow I_f = I_o \frac{R_{E1}}{R_f + R_{E1}}$$

$$\beta = \frac{R_{E1}}{R_f + R_{E2}}$$

$$R' = R_f + R_{E1}$$





$$A_I = +h_{fe} \cdot \frac{(h_{fe} R_{C_1})}{R_{C_1} + h_{ie} + (h_{fe}+1) R_{E_2}} \quad \frac{(R_s \| R_B \| R')}{(R_s \| R_B \| R') + h_{ie}}$$

$$A_{If} = \frac{A_I}{1+\beta A_I}$$

$$R_{if} = \frac{(R_s \| h_{ie} \| R_B \| R')}{1+\beta A_I}$$

$$A_{vf} = A_I \frac{R_o}{R_s}$$

$$R'_{of} = R_{C_2} (1+\beta A_i)$$