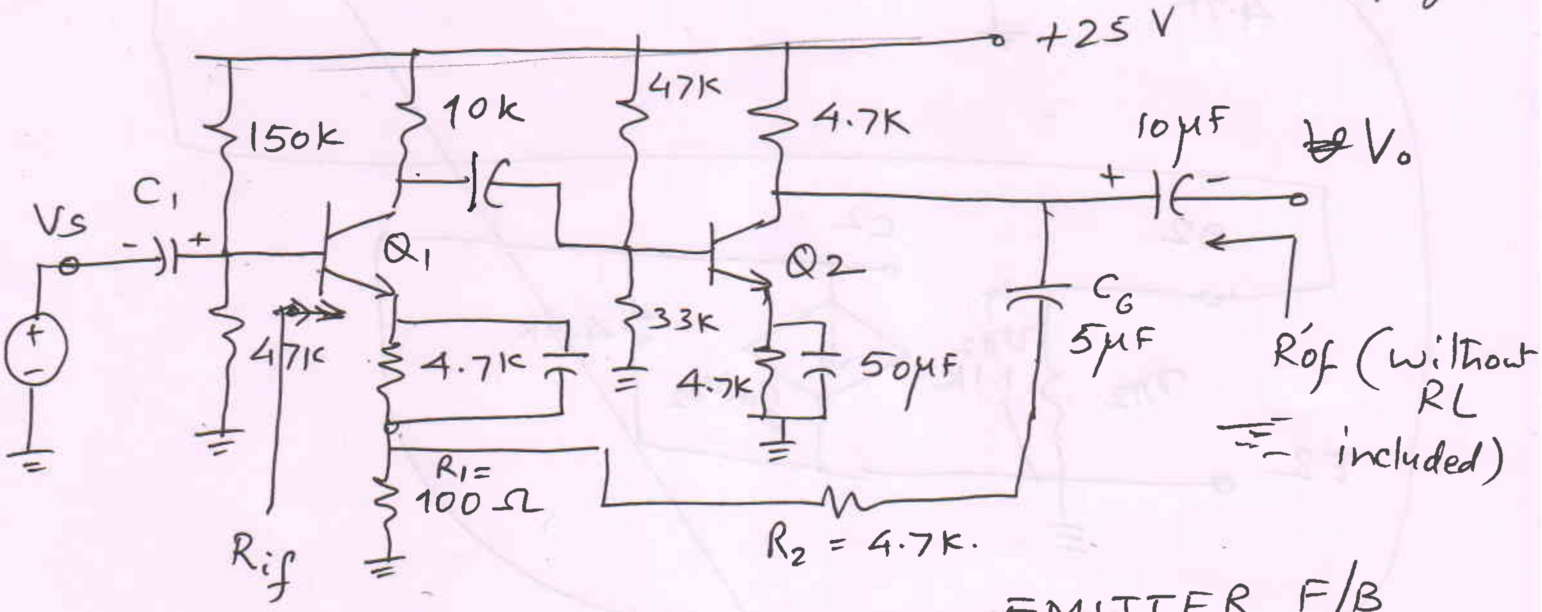
VOLTAGE - SERIES

Solved Example from Millman & Halkias pp 480. (1)

Calculate A_{vf}, R_{of} and R_{if}. Assume $R_s = 0$, $\beta = h_{fe} = 50$

$r_\pi = h_{ie} = 1.1\,k$, r_o (Early Effect) $= \infty$ and both BJTs are identical.

Note that no separate R_L is connected. See the equivalent model on next page.



SECOND - COLLECTOR - TO - FIRST - EMITTER F/B

Calculate Overall Voltage Gain without feedback

$A_V = A_{V1} \cdot A_{V2}$.

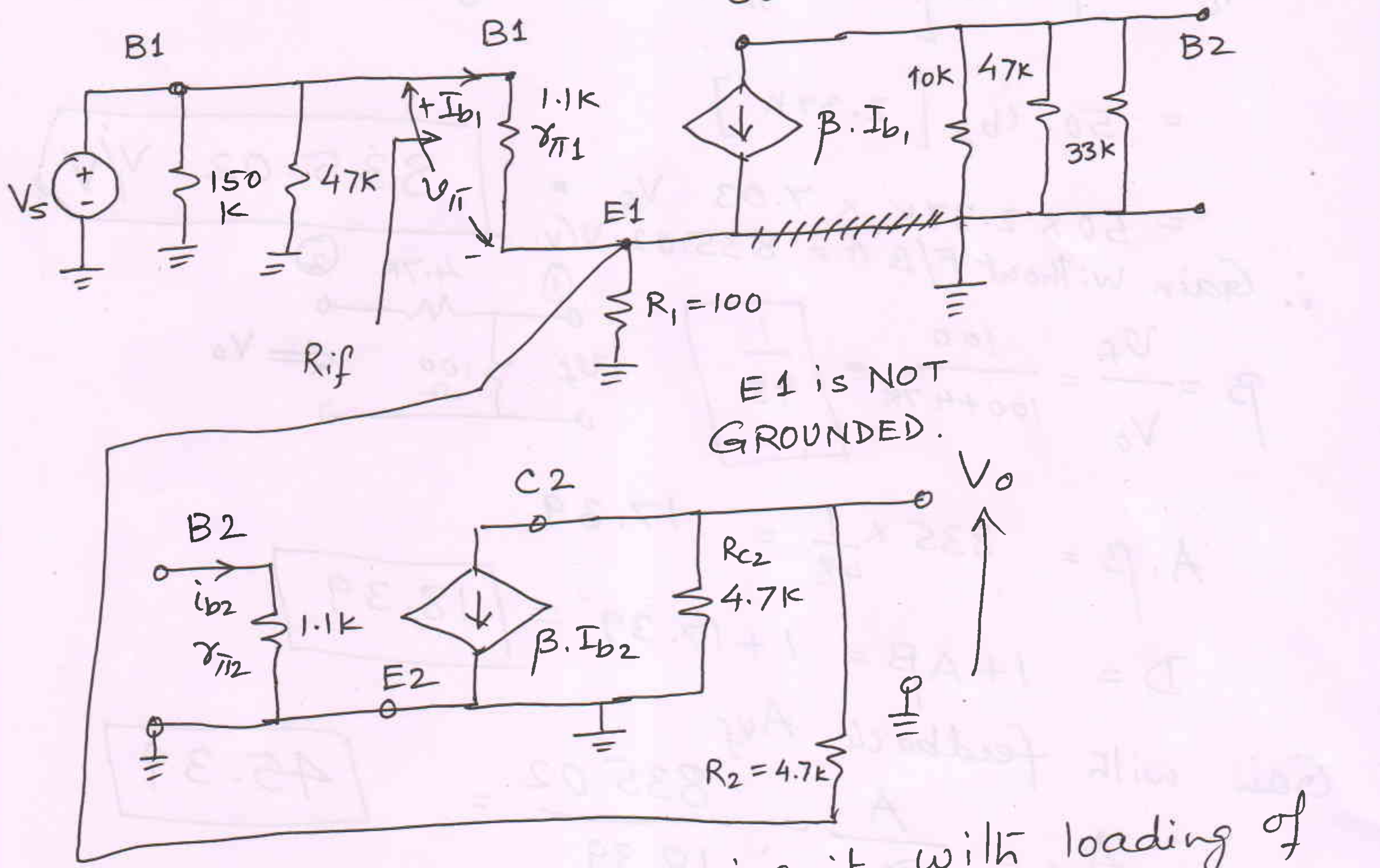
Effective load in collector of Q_1 is $R_{C1} = 10K \,//\, 47K \,//\, 33k \,//\, r_{\pi 2} = 942.8\,\Omega$

Effective load in collector of Q2 is $R_{C2} = 4.7k \,//\, (R_1 + R_2)$ the feedback resistors

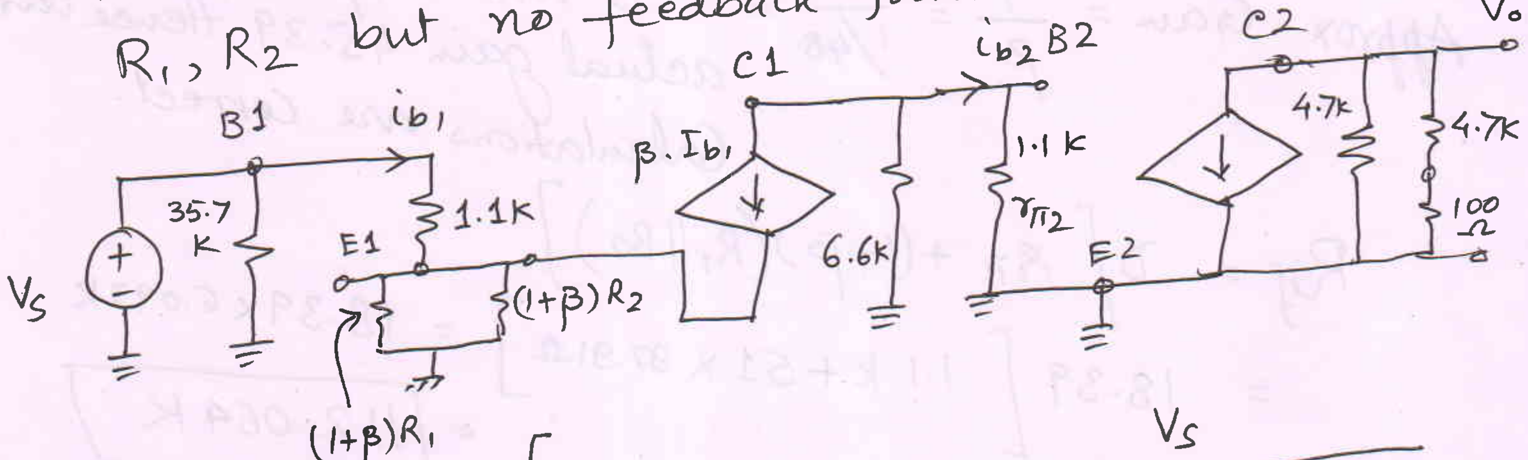
$= 4.7k \,//\, 4.8K = 2374\,\Omega = 2.374\,K$

$g_m = \dfrac{\beta}{r_\pi} =$ $\qquad r_\pi = \dfrac{\beta}{g_m}$.

The small signal model is drawn here: ②



Now redraw above circuit with loading of R_1, R_2 but no feedback from C2 to E1.



$$i_{b_1} = \frac{Vs}{1.1K + 51[4.7K \| 0.1K]} = \frac{Vs}{1.1K + 4.993K} \approx \cancel{6093\,\Omega}$$

$$= \frac{Vs/6K}{}$$

$$i_{b_2} = (\beta . I_{b_1})\left(\frac{6.6K}{6.6K + 1.1K}\right) = 42.85\, i_{b_1}$$

$$= \frac{42.85}{6K} . Vs = 7.03 V_s$$

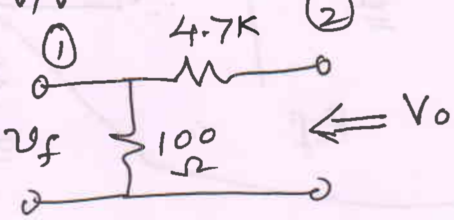
$$V_o = \beta \cdot i_{b2}\left[4.7K \,\|\, (4.7K + 0.1K)\right]$$

$$= 50 \cdot i_{b2}\left[2.37K\right]$$

$$= 50 \times 2.37K \times 7.03\, V_s = 835.02 \text{ V/V}$$

$$\boxed{835.02 \text{ V/V}}$$

∴ Gain without F/B $A = 835.02$



$$\beta = \frac{v_f}{V_o} = \frac{100}{100 + 4.7K} = \boxed{\frac{1}{48}}$$

$$A \cdot \beta = 835 \times \frac{1}{48} = 17.39$$

$$D = 1 + A\beta = 1 + 17.39 = \boxed{18.39}$$

Gain with feedback A_{vf}

$$A_{vf} = \frac{A}{D} = \frac{835.02}{18.39} = \boxed{45.39}$$

Approx. Gain $= \frac{1}{\beta} = \frac{1}{1/48} = 48$ which is quite close to actual gain 45.39 Hence our Calculations are correct.

$$R_{if} = D\left[r_\pi + (1+\beta)(R_1 \| R_2)\right]$$

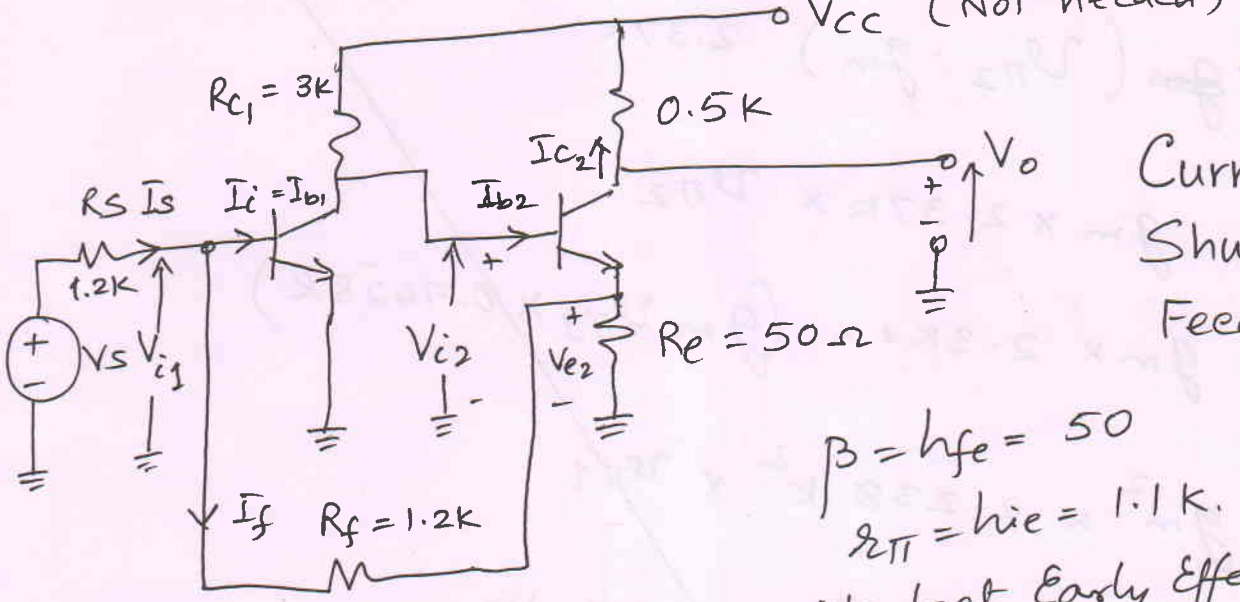
$$= 18.39\left[1.1\,k + 51 \times 97.91\,\Omega\right] = 18.39 \times 6.093K$$

$$= \boxed{112.064K}$$

$$R_o = \frac{R_{C2} \,\|\, (R_1 + R_2)}{D} = \frac{4.7K \,\|\, 4.8K}{D} = \frac{2.37K}{18.39}$$

$$\boxed{= 129.1\,\Omega}$$

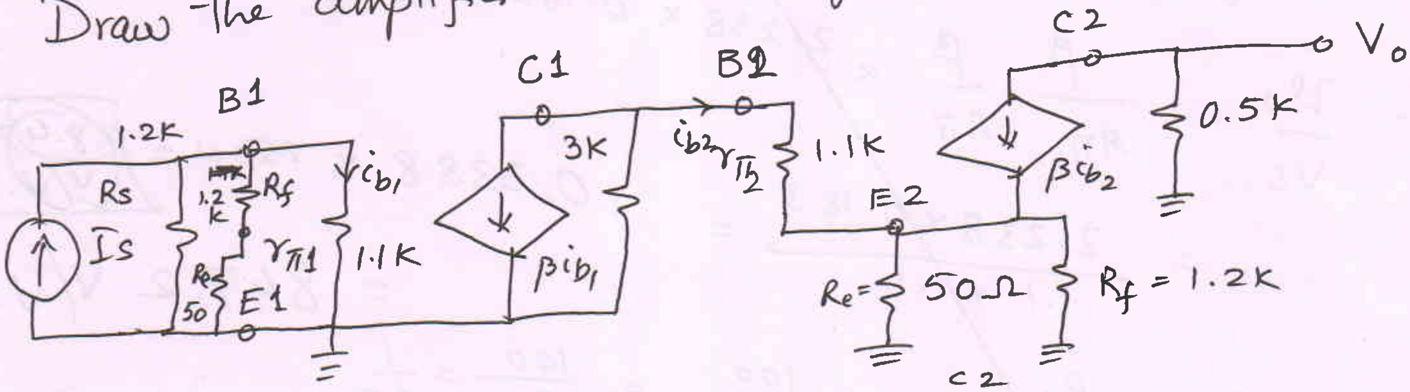
Example on page 489 of Millman & Halkias
Second Emitter to first Base feedback. (Less bias resistors & R_L ~~Rs~~).
Similar to Example 7.4 of Sedra Smith.

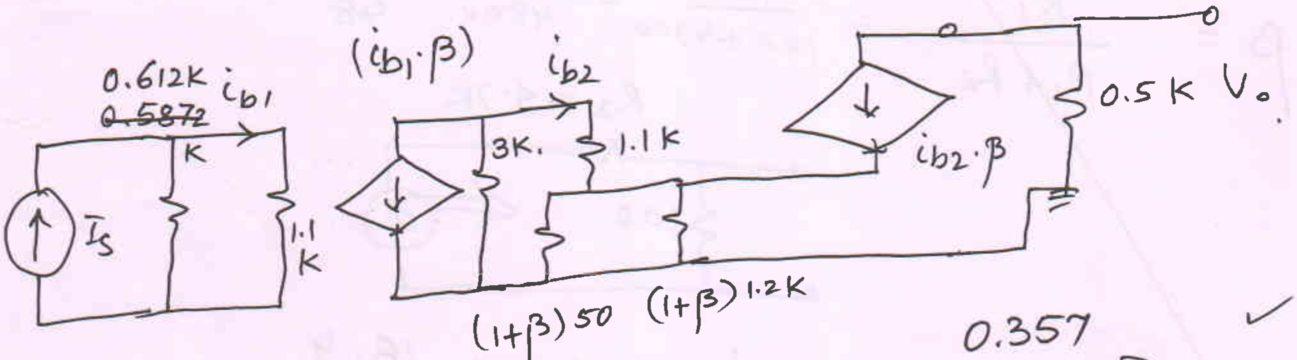


Current Shunt Feedback.

$\beta = h_{fe} = 50$
$r_\pi = h_{ie} = 1.1\,K.$
Neglect Early Effect r_o.

Draw the amplifier with loading of β network.





$$i_{b_1} = \left[\frac{0.612\,K \;(\cancel{.5872\,K})}{0.612\,K \;(\cancel{.5872\,K}) + 1.1\,K}\right] \cdot I_s = 0.357 \;(\cancel{0.348})\; I_s.$$

$$R_{i2} = r_{\pi 2} + (1+\beta)(Re \,||\, R_f) = 1.1k + 51\,[50\Omega \,//\, 1.2K] = 3.548\,K$$

$$i_{b_2} = [\beta \cdot i_{b_1}]\,\frac{3K}{3K + 3.548K} = \frac{50 \times 3k}{6.548\,k} \cdot i_{b_1} = 22.907\, i_{b_1}$$

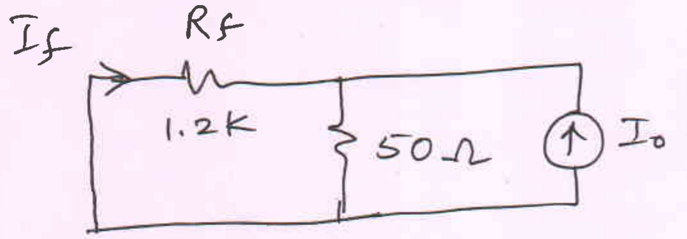
$$i_{b2} = 22.907\, i_{b1} = 22.907 \times \overset{0.357}{\cancel{0.348}} \times I_s$$

$$= \overset{8.191}{\cancel{7.973}}\, I_s$$

$$i_{c2} = I_o = \beta \cdot i_{b2} = 50 \times \overset{8.191}{\cancel{7.973}}\, I_s = \overset{409.5}{\cancel{398.6}}\, I_s$$

$\therefore$ Current Gain w/o feedback

$$A_I = \frac{I_o}{I_s} = \frac{i_{c2}}{I_s} = \boxed{\overset{\cancel{398.6}}{409.5}}$$



$$\beta = \frac{I_f}{I_o} = \left[\frac{50}{50+1.2K}\right] = 0.04 = \frac{1}{25}$$

$$\left[\text{Approx. } A_I = \frac{1}{\beta} = 25\right].$$

$$D = 1 + A_I\beta = 1 + 409.5 \times \frac{1}{25} = 1 + 16.38 = 17.38$$

$$A_{If} = A/D = 409.5/17.38 = \boxed{23.56}$$

$$A_{vf} = \frac{V_o}{V_s} = \frac{-I_{c2} \cdot R_{c2}}{I_s \cdot R_s} = A_I \cdot \frac{0.5K}{1.2K} = \boxed{9.81 \text{ V/V.}}$$

R_i without f/b = ~~R_{i2}~~ $0.612K \,\|\, 1.1K = 379\,\Omega$

$R_{if} = R_i/D = 379/17.38 = \boxed{21.84\,\Omega}$

If R_s is added to this it is $1.2K + 21.84\,\Omega$

$R_o = R_{c2} = 0.5K$

R_{of} is not altered since output Voltage is not ~~at~~ sampled. Since 50Ω is inserted in series with current source, its effect on V_o is negligible.