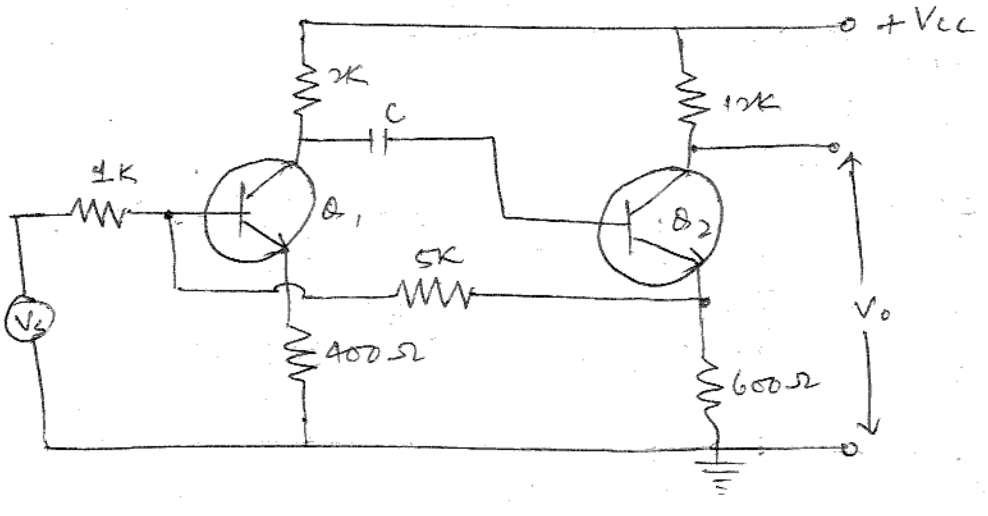
(7) Solution:

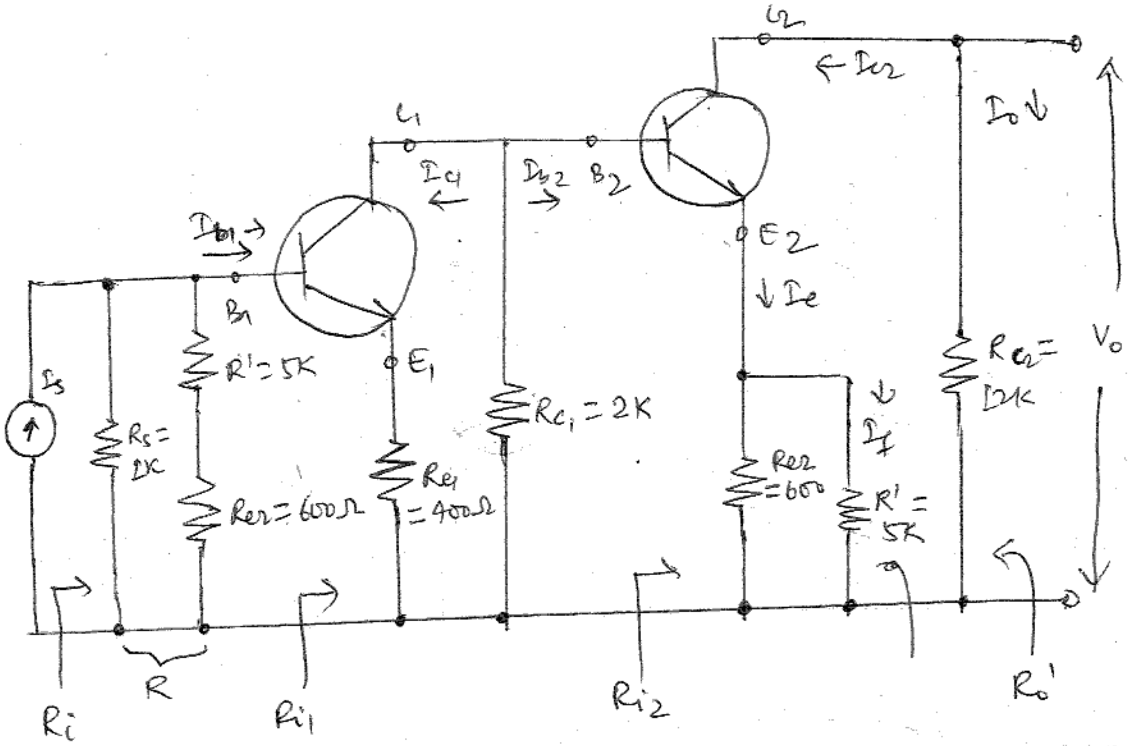


Step-I: Identify topology.

- The feedback is given from emitter of Q_2 to the base of Q_1.
- If $I_o = 0$, the f/b current through 5K resistor is zero, hence it is current sampling.
- As f/b signal ~~signal~~ is mixed in shunt with i/p, the amplifier is current shunt f/b amplifier.

Step-2 & Step-3

- The i/p ckt of an amplifier, without f/b is obtained by opening the o/p loop of the emitter of Q_2 ($I_o = 0$).
- This places R' (5K) in series with R_e (600Ω) from base to emitter of Q_1.
- The o/p ckt. is found by shorting the i/p node, ie. making $V_i = 0$. This places R' (5K) in parallel with R_e. The resultant equivalent ckt. can be drawn as,



Step-4 : To find open circuit transfer gain.

$$A_I = \frac{I_o}{I_s} = \frac{-I_{c2}}{I_s}$$

$$\boxed{A_I = -\frac{I_{c2}}{I_{b2}} \cdot \frac{I_{b2}}{I_{c1}} \cdot \frac{I_{c1}}{I_{b1}} \cdot \frac{I_{b1}}{I_s}} \quad (1)$$

we know that,

$$\left.\begin{aligned} -\frac{I_{c2}}{I_{b2}} &= A_{i2} = -h_{fe} = -50 \\ \frac{I_{c1}}{I_{b1}} &= A_{i1} = h_{fe} = 50 \end{aligned}\right\} \quad (2)$$

from above fig

$$\boxed{\frac{I_{b2}}{I_{c1}} = \frac{-R_{c1}}{R_{c1} + R_{i2}}} = \frac{-2K}{2K + \left[\frac{0.6 \times 5}{0.6+5}\right]} \quad (3) \quad [\because R_{i2} = R_{e2} \| R']$$

$$= \frac{-2K}{\cancel{4K}}$$

$$\boxed{R_{i2} = h_{ie} + (1+h_{fe})(0.6 \| 5)}$$

$$= h_{ie} + 51 \times \left(\frac{0.6 \times 5}{0.6+5}\right)$$

$$= 1.5 + 51 \times 0.536$$

$$R_{i2} = 28.82\ k\Omega$$

$$\therefore \frac{I_{b2}}{I_{c1}} = \frac{-2}{2+28.82} = -0.0649$$

$$\therefore \boxed{\frac{I_{b2}}{I_{c1}} = -0.0649}$$

Again,

$$\frac{I_{b1}}{I_s} = \frac{R}{R+R_{i1}}$$

$$\cancel{R = 1 + (5 \| 0.6)}$$
$$\cancel{= 1 + \frac{3}{5.6}}$$

$$R = 1 \| 5.6 = \frac{5.6}{6.6} = 0.848$$

$$\& \ R_{i1} = h_{ie} + (1+h_{fe}) \times R_{e1}$$

$$= 1.5 + 51 \times 0.4$$

$$= 21.9$$

$$\therefore \frac{I_{b1}}{I_s} = \frac{0.848}{0.848 + 21.9} = 0.0372$$

$$\boxed{\frac{I_{b1}}{I_s} = 0.0372}$$

$[\because R_{i2} = R_{e2} \| R']$

$$\therefore A_I = (-50) \times (-0.0649) \times 50 \times (0.0372) = 6.0357$$

$$\boxed{A_I = 6}$$ //

Step-5: To Calculate β

$$\beta = \frac{I_f}{I_o} = \frac{R_{e2}}{R_{e2}+R'} = \frac{0.6}{0.6+5} = 0.107$$

$$\boxed{\beta = 0.107}$$

Step-6: To calculate D, A_{if}, A_{vf}; R_{if}, R_{of}

$$D = 1+\beta A_I$$
$$= 1+0.107\times 6$$
$$\boxed{D = 1.642}$$

$$A_{if} = \frac{A_I}{D} = \frac{6}{1.642} = \boxed{3.654}$$

$$A_{vf} = \frac{V_o}{V_s} = \frac{-I_{c2}R_{c2}}{I_s R_s} = \frac{A_{if}R_{c2}}{R_s}$$

$$= \frac{3.654\times 12}{1}$$

$$= \boxed{43.848}$$

$$R_i = R \,\|\, R_{i1}$$
$$= 0.848 \,\|\, 21.9$$
$$= \frac{0.848\times 21.9}{22.748}$$
$$= 0.81638\ k\Omega$$

$$\boxed{R_i = 816.38\ \Omega}$$

$$R_{if} = \frac{R_i}{D} = \frac{816.38}{1.642} = \boxed{497.186\,\Omega}$$

$R_o = \infty$

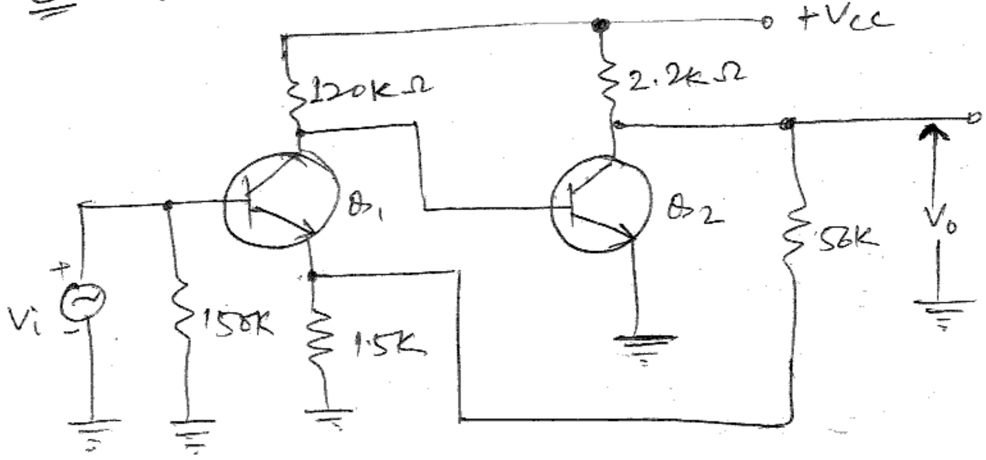
$$\boxed{R_{of} = R_o D = \infty}$$

$$R_o' = R_o \| R_{e2} = \infty \| 12k = \boxed{12k}$$

$$R_{of}' = R_o' \frac{1+\beta A_i}{1+\beta A_i} = R_o' = \boxed{12k}$$

$, R_{of}$

(8) soln :

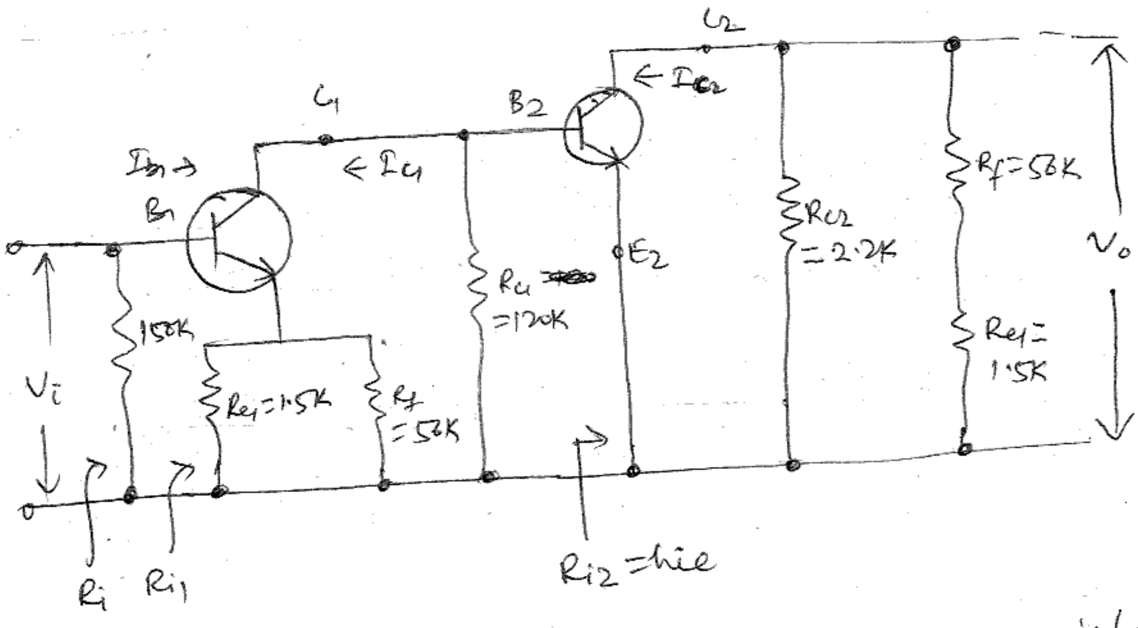


Step-I : Identify topology.

- The f/b voltage is applied across 1.5K, which is in series with the i/p signal.
Hence, f/b is voltage series feedback.

Step-II : To find the i/p and o/p circuit.

- To find the i/p circuit, set $V_o = 0$, which gives parallel combn of R_{e1} with R_f at E_1.
- To find o/p ckt, set $I_i = 0$ by opening the i/p node, E_1 at emitter of Q_1, which gives the series combination of R_f and R_{e1} across the o/p. The resultant fig. is given below.



<u>Step-4</u>: Find the open loop voltage gain (A_v)

$R_{L2} = R_{C2} \| (R_f + R_{e1})$
(loop 2)

$= 2.2 \| 57.5$

$= \dfrac{2.2 \times 57.5}{59.7}$

$\boxed{R_{L2} = 2.12\,K}$

Since, $h_{oe} R_{L2} = 10^{-6} \times 2.119\,K < 0.1$

∴ The approximate analysis can be used as

$A_{i2} = -h_{fe} = -200$

$R_{i2} = h_{ie} = 2K\Omega$

$A_{v2} = \dfrac{A_{i2} R_{L2}}{R_{i2}} = \dfrac{-\cancel{200}\,100 \times 2.12}{2}$

$\boxed{A_{v2} = -212}$

$R_{L1} = R_{C1} \| R_{i2} = 120 \| 2 = \dfrac{120 \times 2}{122}$

$\boxed{R_{L1} = 1.967K}$

Since, $h_{oe} R_{L1} = 10^{-6} \times 1.967 < 0.1$.

$\therefore A_{i1} = -h_{fe} = -200$

$$R_{i1} = h_{ie} + (1+h_{fe}) R_e$$

$$= 2 + (1+200)(1.5 \| 56)$$

$$= 2 + 201 \times \frac{1.5 \times 56}{57.5}$$

$$= 2 + 293.63$$

$$\boxed{R_{i1} = 295.63\,K}$$

$$A_{v1} = \frac{A_{i1} R_{L1}}{R_{i1}} = \frac{-200 \times 1.967}{295.63}$$

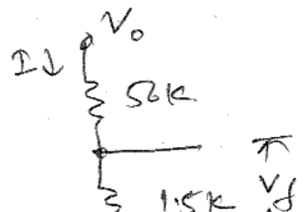
$$\boxed{A_{v1} = -1.33}$$

Now, the overall gain without feedback is,

$$A_v = A_{v1} \times A_{v2}$$
$$= (-1.33)(-212)$$

$$\boxed{A_v = 282}$$

Step-5: Calculate β.



$$\beta = \frac{V_f}{V_o} = \frac{\cancel{I} \times 1.5K}{\cancel{I}(56K + 1.5K)}$$

$$\beta = \frac{1.5}{57.5}$$

$$\boxed{\beta = 0.026}$$

Step-6 :- To calculate D, A_{vf}, R_{if}, R_{of}

$$D = 1 + \beta A_v$$
$$= 1 + (0.026)\,281.82$$
$$\boxed{D = 8.327}$$

$$A_{vf} = \frac{A_v}{D} = \frac{282}{8.327} = \boxed{33.86}$$

$$R_i = R \parallel R_{ii}$$
$$= \cancel{150 \parallel (1.5 \parallel 56)}$$
$$= \cancel{150 \parallel \left(\frac{1.5 \times 56}{1.5 + 56}\right) = 150 \parallel}$$
$$= 150 \parallel 295.63$$
$$= \frac{150 \times 295.63}{150 + 295.63} = \frac{44344.5}{445.63}$$
$$\boxed{R_i = 99.5K}$$

$$R_{if} = R_i \times D$$
$$= 99.5 \times 8.327$$
$$\boxed{R_{if} = 828.53K}$$

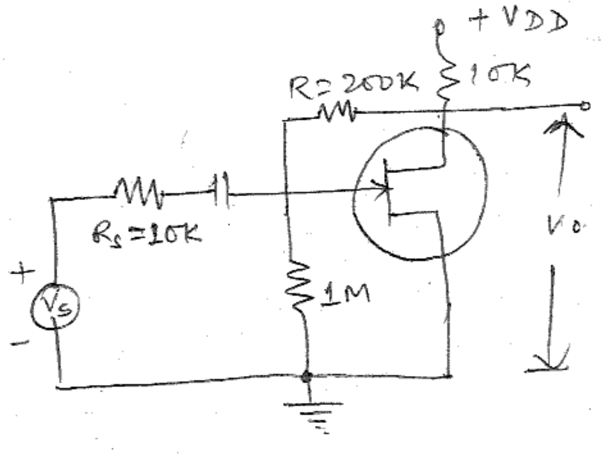
$$R_o = \frac{1}{h_{oe}} = \frac{1}{10^{-6}} = 10^6 = \boxed{1 M\Omega}$$

$$R_{of} = \frac{R_o}{D} = \frac{\cancel{10^6}\ \cancel{10^3K}\ 10^6}{8.327} = \boxed{120 k\Omega}$$

$$R_o' = R_o \parallel R_{C2} \parallel (R_f + R_{E1}) = R_o \parallel R_{L2}$$
$$= 1M \parallel 2.119K = 1000 \parallel 2.119K$$
$$= \frac{1000 \times 2.119}{1002.119} = \boxed{2.1145K}$$

$$R_{of}' = \frac{R_o'}{D} = \frac{2.1145}{8.327} = \boxed{254\ \Omega}$$

(9) Sol:



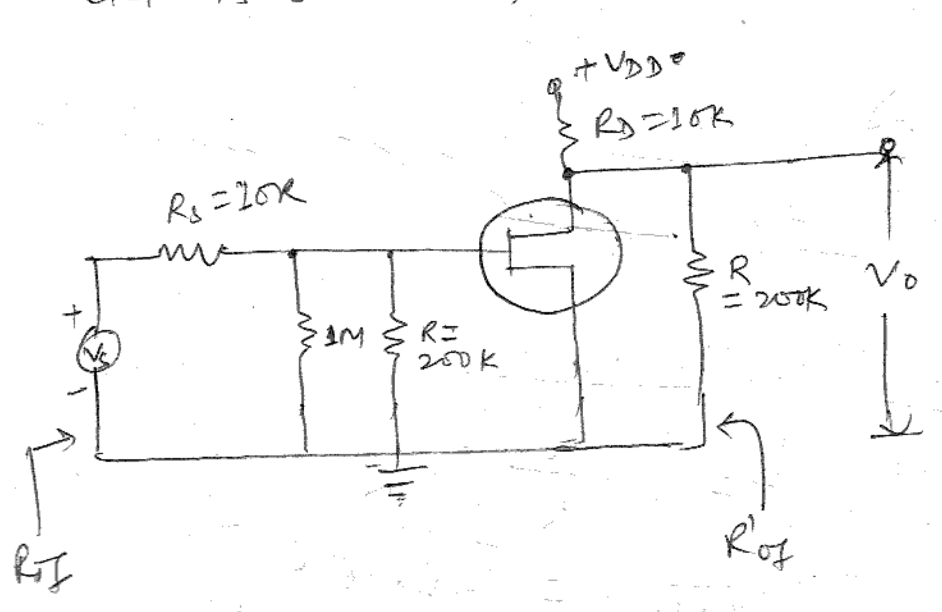
Step I: To identify the topology.

- By making $V_o = 0$, feedback current becomes zero. Hence, it is a voltage sampling. The f/b is fed in shunt with the i/p signal & thus the topology is voltage shunt feedback.

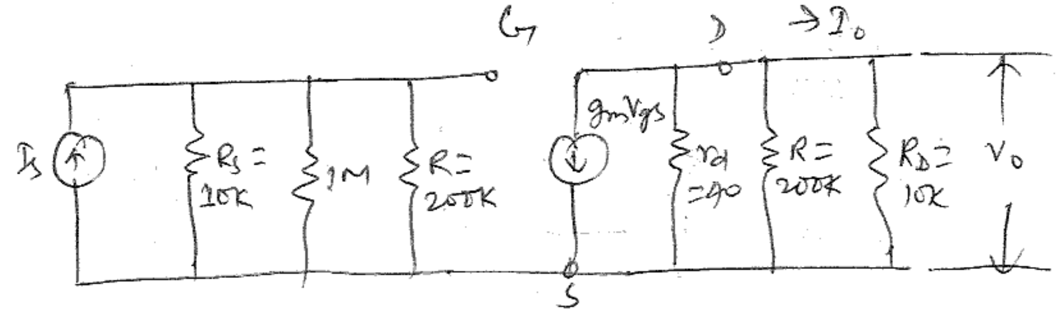
Step-II & **Step-III**: To find the i/p & o/p ckt.

- To find the i/p circuit, set $V_o = 0$. This places resistor R across the i/p.

- To find o/p ckt, set $V_i = 0$. This places resistor R' across the o/p. The resultant ckt is shown as,



Step-4: By replacing FET with its equivalent ckt.



Step-5: To find open loop transresistance

$$R_m = \frac{V_o}{I_s} = \frac{-g_m V_{gs} R_{eff}}{I_s}$$

where $R_{eff} = r_d \| R \| R_D = 40 \| 200 \| 10$
$= 7.69 k\Omega$.

& $V_{gs} = I_s R_i$
$= I_s (R_s \| 1M \| 200K)$
$= I_s (10K \| 1M \| 200K)$
$= 9.43 \times 10^3 I_s$

$$\therefore R_m = \frac{-g_m \times 9.43 \times 10^3 \cancel{I_s} \times 7.69 \times 10^3}{\cancel{I_s}}$$

$= -2.5 \times 10^{-3} \times 9.43 \times 10^3 \times 7.69 \times 10^3$

$\boxed{R_m = -181.29K}$

Step-6: To calculate β.

$$\beta = \frac{I_f}{I_o} = \frac{V_i - V_o}{V_o R} = -\frac{1}{R} \quad (\because V_o > V_i)$$

$$= \frac{-1}{200 \times 10^3} = \boxed{-5 \times 10^{-6}}$$

Step-7 : To calculate D, R_{mf}, A_{vf}, R_{of} & R'_{of}.

$D = 1 + \beta R_m$

$= 1 + (-5 \times 10^{-6})(-181.29)$

$\boxed{D = 1.9}$

$R_{mf} = \frac{R_m}{D} = \frac{\cancel{*}181.29}{1.9} = \boxed{95K.}$ //

$\Rightarrow A_{vf} = \frac{V_o}{V_S} = \frac{V_o}{I_s R_s} = \frac{R_{mf}}{R_s}$ $\qquad \because \left[R_{mf} = \frac{V_o}{I_s}\right]$

$R_i = \cancel{9.43 \times 10^3}$ $\quad R_s \| \cancel{M} \| R = \cancel{10 \| 1 \| 100 R}$

$= \cancel{0.01 \| 1 \| 0.2} = \cancel{0.01 \|}$ $\left(\frac{1 \times 0.2}{1+0.2}\right)$

$= \cancel{(0.01 \| 0.167)}$

$= \cancel{\frac{0.01837}{0.277}}$

$R_i = 9.43 \times 10^3 \Omega$, $\quad R_{if} = \frac{R_i}{D} = \frac{9.43 \times 10^3}{1.9}$

$\boxed{R_{if} = 4.963 \Omega}$ //

$R_o' = R_{eff} = r_d \| R \| R_D$

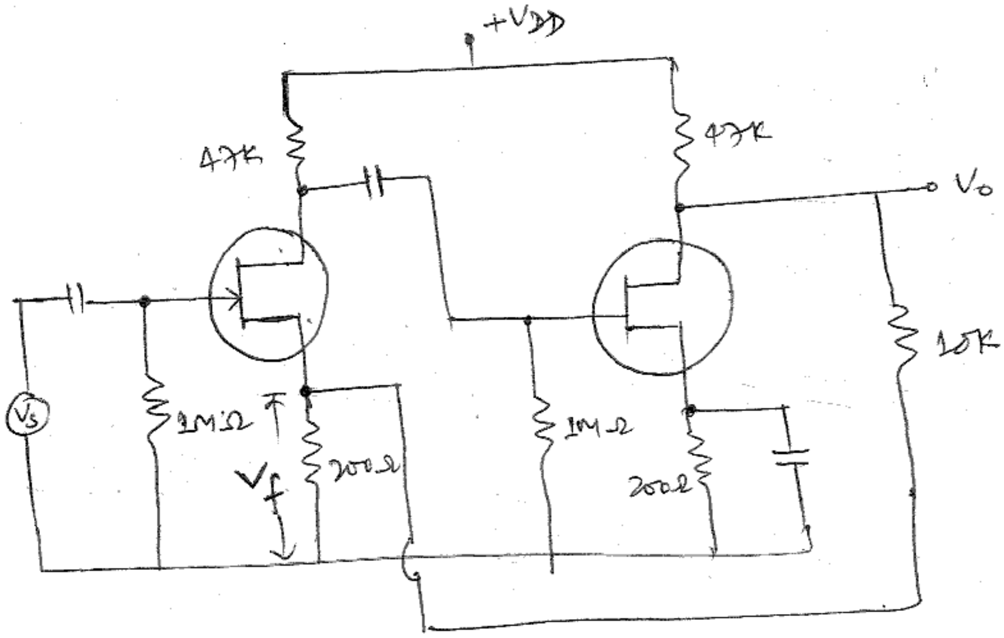
$= 40K \| 200K \| 20K$

$= \boxed{7.69 K\Omega}$.

$R_{of} = \frac{R'_o}{D} = \frac{7.69 \times 10^3}{1.9} = \boxed{4 K\Omega}$

$R_{of}' = \frac{R_{of}}{D} = \frac{4}{1.9} = \boxed{2.2 K\Omega}$

(10) Soln:



Step-1. To identify topology.

- By shorting o/p voltage ($V_o = 0$), V_f becomes zero.
& ~~hence it~~.

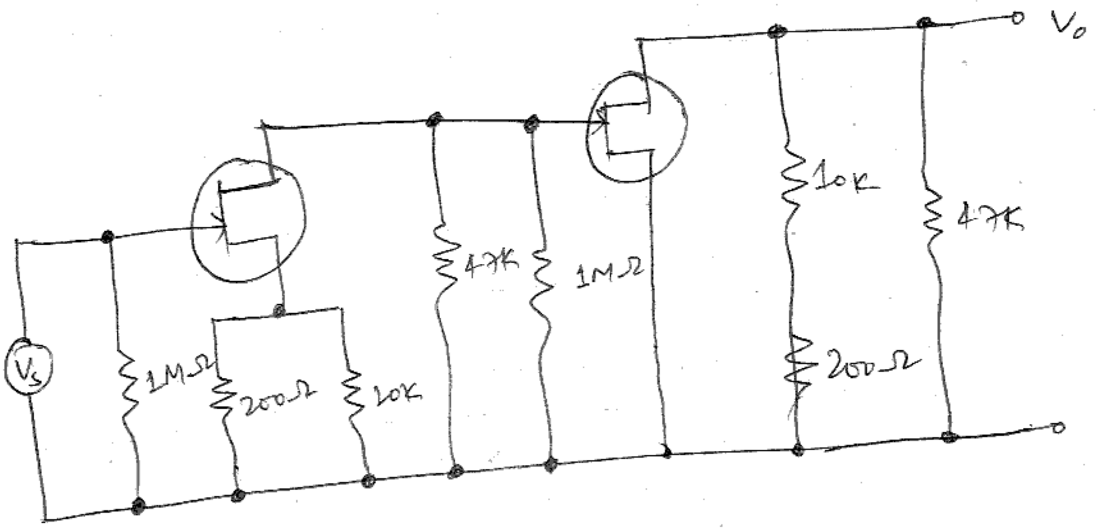
- The f/b voltage is applied in series with the i/p voltage hence, the topology is voltage series f/b.

Step-2 & Step-3: To find the i/p & o/p ckt.

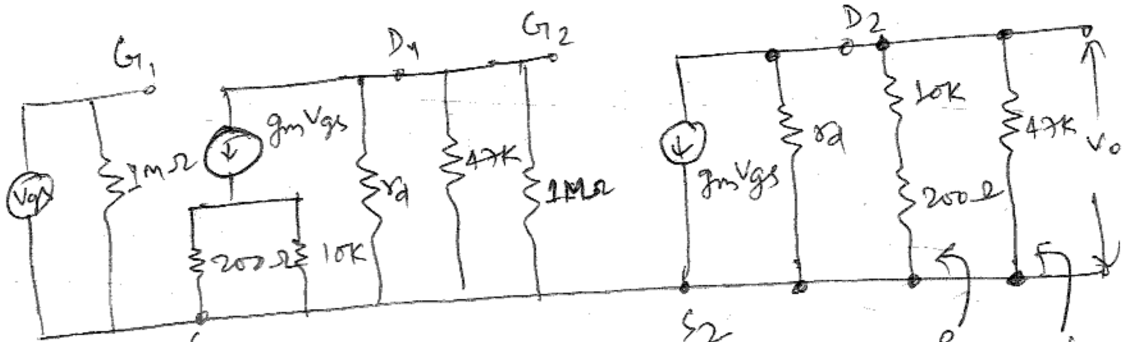
- To find the i/p ckt, set $V_o = 0$, where, 10K will be in parallel with 200 Ω at first source.

- To find the o/p ckt, set $I_i = 0$, where, 10K and 200 Ω are in series across the o/p.

The resultant ckt. diagram becomes:



Step-4: Replacing FET with its equivalent ckt.



Step-5: To find open loop transfer gain.

$$A_v = \frac{V_o}{V_s} = A_{v_1} A_{v_2}.$$

$$A_{v_2} = \frac{-\mu R_{L2}}{R_{L2} + r_d}$$

where, $R_{L2} = (10K + 0.2K) \parallel 47K$
$= 8.38K$

$$\therefore A_{v_2} = \frac{-40 \times 8.38 \times 10^3}{8.38 \times 10^3 + 10 \times 10^3} = \boxed{-18.237}$$

$$A_{v_1} = \frac{-\mu R_{Deff}}{r_d + R_{Deff} + (1+\mu) R_S}$$

where $R_{Deff} = R_D \parallel R_{G_2} = 47k \parallel 1M$
$= 44.89 k\Omega$

$$\therefore A_{v_1} = \frac{-40 \times 44.98 \times 10^3}{10 \times 10^3 + 44.89 \times 10^3 + (1+40)(10k \parallel 0.2)}$$
$= -28.59$

$A_v = -28.59 \times (-18.237)$

$\Rightarrow \boxed{A_v = 521.39}$

Step-6: $\beta = \frac{V_f}{V_o} = \frac{200}{10 \times 10^3} = 0.02$

Step-7:

$\Rightarrow D = 1 + \beta A_v = 1 + 0.02 \times 521.39 = \boxed{11.42}$

$\Rightarrow A_{vf} = \frac{A_v}{D} = \frac{521.39}{11.42} = \boxed{45.62}$

$R_i = R_G = 1M\Omega$

$\Rightarrow R_{if} = R_i \times D = 1 \times 11.42 = \boxed{11.42 M\Omega}$

$R_o = r_d = \boxed{10k}$

$\Rightarrow R_{of} = \frac{R_o}{D} = \frac{10}{11.42} = \boxed{0.8756 k\Omega}$

$R_o' = r_d \parallel R_2 = 10k \parallel 8.38k = \boxed{4.559 k\Omega}$

$\Rightarrow R_{of}' = \frac{R_o'}{D} = \frac{4.559 k\Omega}{11.42} = \boxed{0.399 k\Omega}$

⑥ Effect of negative feedback on i/p & o/p resistance of current shunt f/b amplifier.

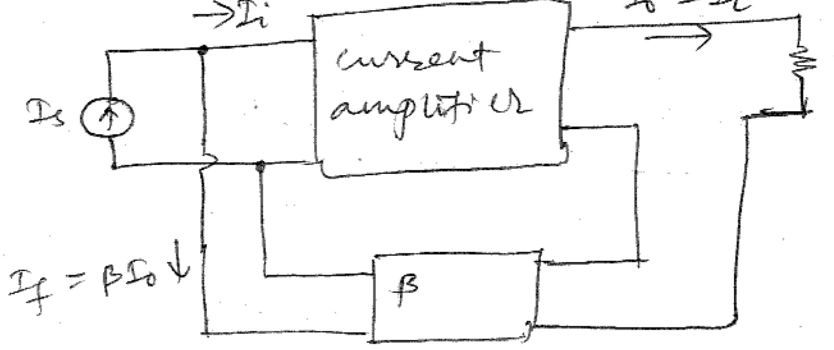
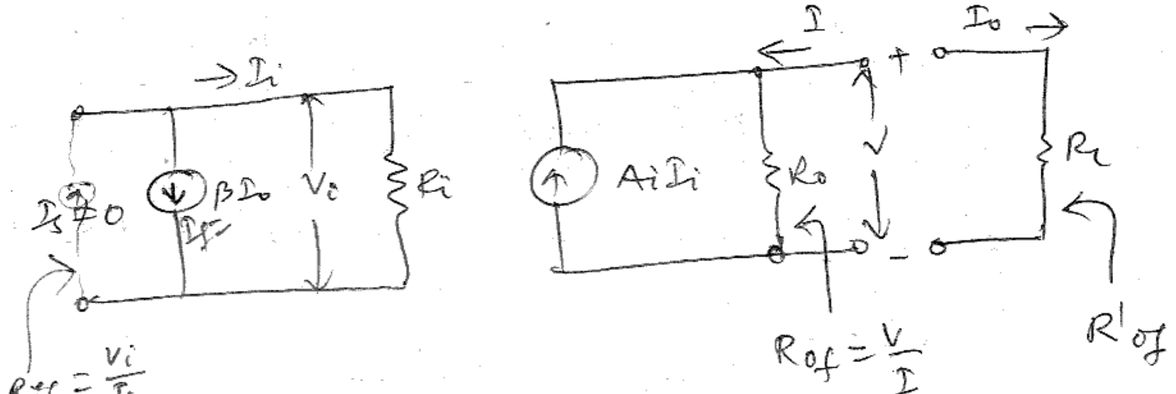


fig- current amplifier with current shunt-feedback.



In this topology, the o/p resistance can be measured by open circuiting the i/p source $I_s = 0$, and looking into the o/p terminals, with R_L disconnected, as shown in above fig.

Applying the KCL to the o/p node, we get,

$$I = \frac{V}{R_o} - A_i I_i \quad — ①$$

The i/p current is given as,

$$I_i = -I_f = -\beta I_o \quad [\because I_s = 0]$$

$$\boxed{I_i = \beta I} \quad [\because I = -I_o] \quad — ②$$

Solving eqn ① & ②.

$$I = \frac{v}{R_o} - A_i \beta I$$

$$I(1 + A_i\beta) = \frac{v}{R_o}$$

$$\boxed{R_{of} = \frac{v}{I} = R_o(1 + A_i\beta)} \quad \text{— ③}$$

open loop current gain without taking R_L in a content.

$$R_{of}' = R_{of} \parallel R_L$$

$$= R_o(1 + A_i\beta) \parallel R_L$$

$$= \frac{R_o(1+\beta A_i) \cdot R_L}{R_o(1+\beta A_i) + R_L} = \frac{R_o R_L}{R_o + R_L + \beta A_i R_o}$$

Dividing num. & den. by $R_o + R_L$, we ...

$$R_{of}' = \frac{\dfrac{R_o R_L (1+\beta A_i)}{R_o + R_L}}{1 + \dfrac{\beta A_i R_o}{R_o + R_L}}$$

$$\boxed{R_{of}' = \frac{R_o (1+\beta A_i)}{(1+\beta A_i)}} \quad \text{— ④}$$

$$\because R_o' = \frac{R_o R_L}{R_o + R_L} \quad \& \quad A_I = \frac{A_i R_o}{R_o + R_L}.$$

Here, A_I is the open loop current gain taking R_L in account.

Gain with feedback $= A_{if} = \dfrac{A_i}{1+\beta A_i}$ → decreases.

I/p resistance $(R_{if}) = \dfrac{R_i}{1+\beta A_i}$ → decreases

O/p resistance $(R_{of}) = R_o(1+\beta G_m)$ → increases.

Stability & frequency response → improves ~~increase~~

Frequency distortion → Reduces.

Noise & non-linear distortion → reduces.

Applying KCL to the i/p node, we get,

$$I_s = I_i + I_f$$
$$= I_i + \beta I_o \quad -(5)$$

$V = IR$

$V/R = I$

$$\text{O/p current } (I_o) = \frac{A_i I_i R_o}{R_o + R_L}$$
$$= \cancel{A_I}\, A_I I_i \quad —— (6) \text{ sub in } (5)$$

where, $\boxed{A_I = \dfrac{A_i R_o}{R_o + R_L}}$

$$I_s = I_i + \beta(A_I I_i)$$
$$= I_i(1+\beta A_I)$$

The i/p resistance with f/b is given as,

$$R_{if} = \frac{V_i}{I_s} = \frac{V_i}{I_i(1+\beta A_I)}$$

$$\therefore \boxed{R_{if} = \frac{R_i}{(1+\beta A_I)}}$$

//.