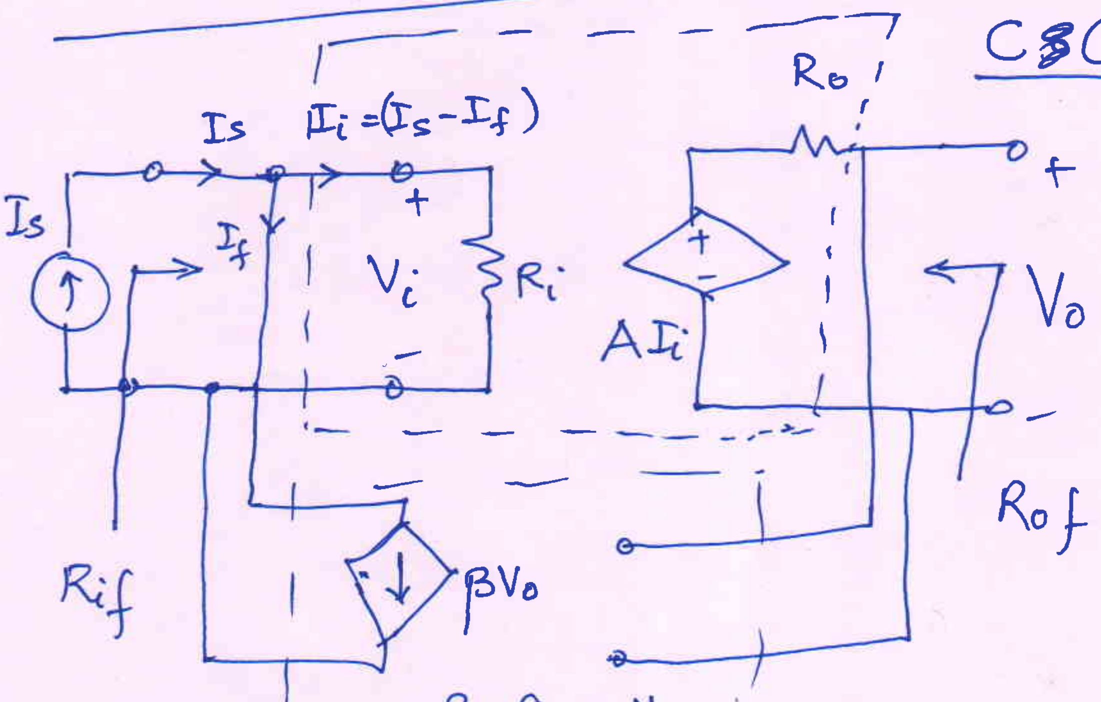
SHUNT- SHUNT FEEDBACK

VOLTAGE FEEDBACK INSERTED IN SHUNT WITH INPUT VOLTAGE SIGNAL

CCCVS



β Circuit

Amplifier has input resistance R_i, Output is a current controlled voltage source $A \cdot I_i$ where A has units of Trans-resistance. R_o is the output resistance. R_{if} and R_{of} are values when feedback is applied. β circuit senses output voltage V_o and produces feedback current I_f such that

$$I_f = \beta V_o$$ where β has units of transconductance

Closed Loop Gain with feedback is defined as — — — (1)

$$A_f \equiv V_o / I_s$$

and is given by

$$A_f = \frac{A}{1 + A\beta}$$

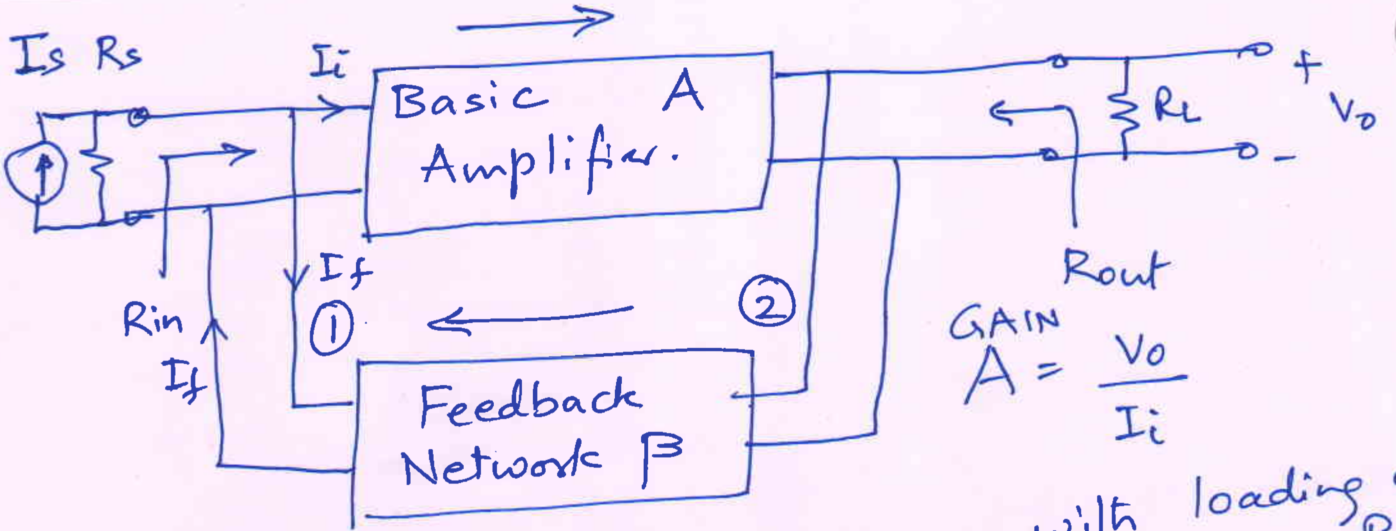
$\because$ feedback is "inserted" in shunt with voltage/current ~~sh~~ source at input terminals, feedback will cause input resistance to decrease by a factor of D.

$$\therefore \; R_{if} = \frac{R_i}{D} = \frac{R_i}{1+A\beta}$$

Similarly output resistance with feedback will also decrease due to parallel connection (Voltage Sensing) of β to output.

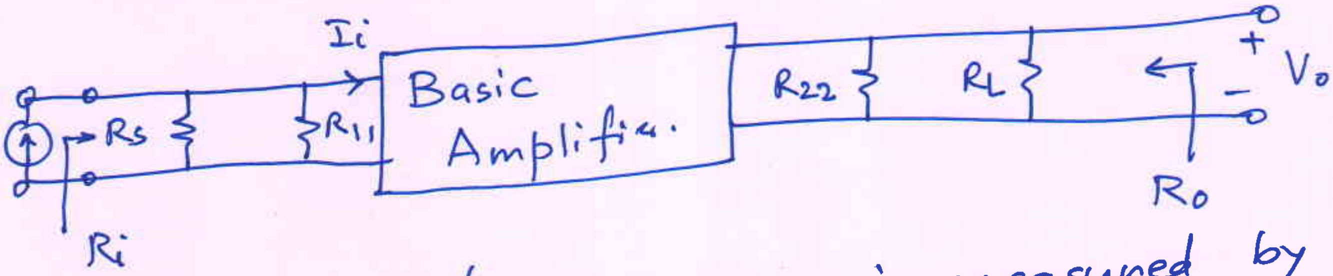
$$\therefore \; R_{of} = \frac{R_o}{D} = \frac{R_o}{1+A\beta}$$

Now we will consider a practical shunt-shunt amplifier with feedback.

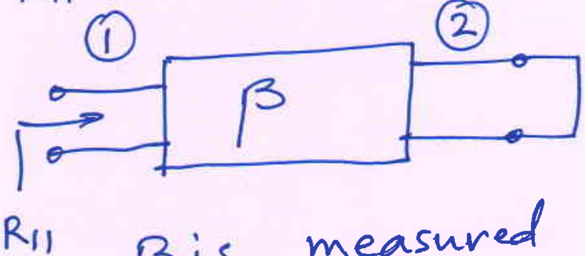


GAIN $A = \frac{V_o}{I_i}$

The above circuit is redrawn with loading of β



R_{11} is measured by

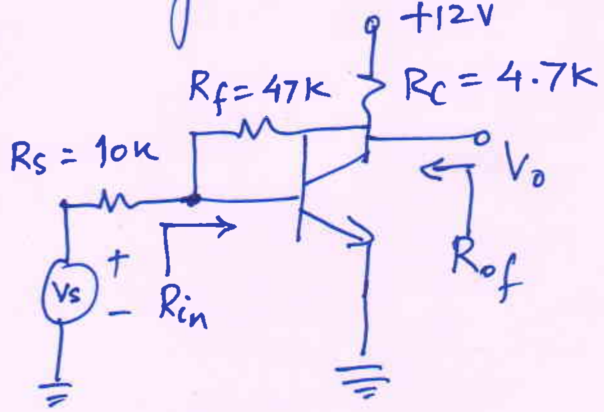


R_{22} is measured by

β is measured from

$$\beta = \left.\frac{I_f}{V_o}\right|_{V_1 = 0}$$

Analyze following Self Bias Circuit as a Negative Feedback Amplifier. (4)



Assume current gain $\beta = 100$.

Find small signal Voltage Gain A_{vf}, R_{in} and R_{of}.

Calculate I_C & V_C.

$V_E = 0$; $V_{BE} = 0.7$ $\therefore$ $V_B = 0.7V$

DC Current flowing into signal generator (neglecting alternating Signal Source)

$$= \frac{0.7V}{R_S = 10K}$$

$$= (.7/10)\,mA = 0.07\,mA$$

Now write KVL from +12V to GND through V_C, R_C, R_f and V_{BE}.

$$V_C = \text{drop across } V_f + V_{BE}$$

$$= (I_B + 0.07mA) \times 47k + 0.7 \quad \text{---} \; (1)$$

$$+12V = I_C R_C + V_C$$

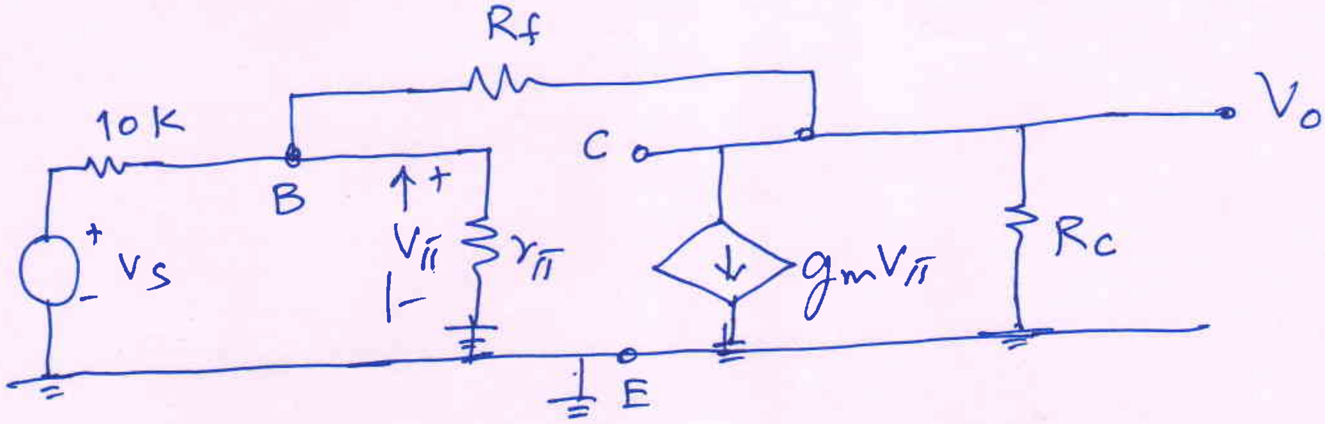
$$\text{or } V_C = 12V - I_C R_C \quad \text{------} \; (2)$$

$$= 12V - \beta . I_B R_C$$

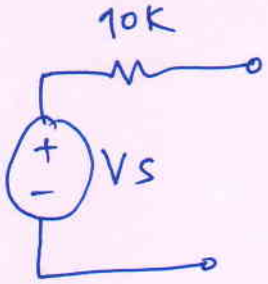
This gives us $I_B = 15\mu A$, $I_C = 1.5mA$; $V_C = 4.7V$

$$g_m = \frac{I_C}{V_T} = 60m\mho \qquad r_\pi = 1.666\,K$$

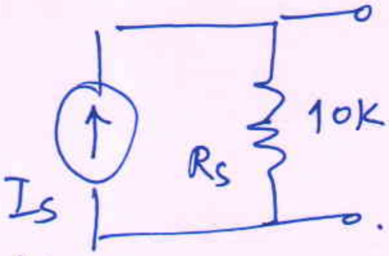
Now we will draw small signal model



Replace



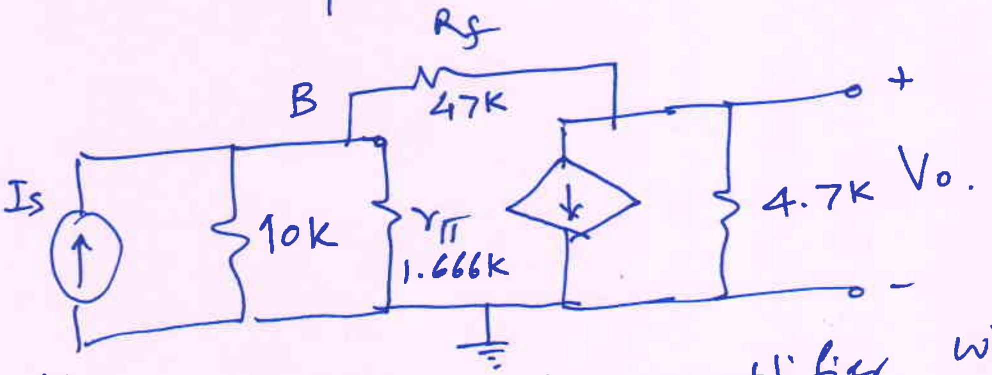
By



$I_s = \frac{V_s}{R_s} = \frac{V_s}{10k}$

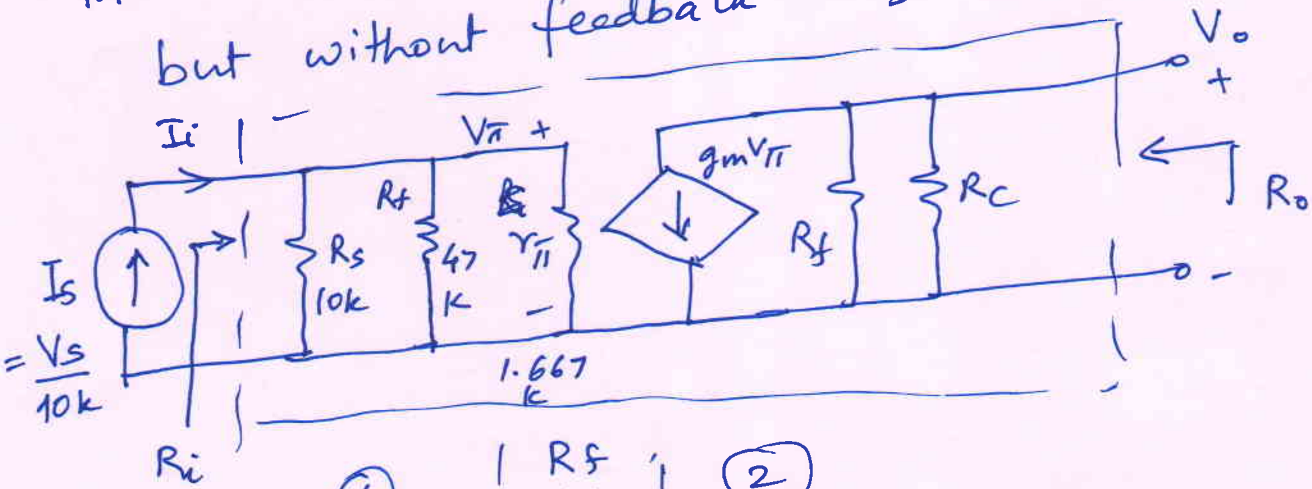
Thevenin Source Representation

Norton Source Representation



$= \frac{V_s}{10k}$

Now draw this amplifier with loading of Rf but without feedback as follows:



Note that to measure R_{11}, we short V_o and then other terminal (Collector) of R_f goes to 0 ∴ R_{11} seen from port 1 is R_f to GND ∴ $R_{11} = R_f$.

Similarly when we measure R_{22}, we short port 1 i.e. Base side terminal of R_f to ground & from Port 2 i.e. collector side, R_f appears are resistance to ground ∴ $R_{22} = R_f$.

So the loading of β network on A is just appearance of R_f in input & Output, both places. Let us calculate Voltage Gain with Feedback.

$$V_\pi = I_i \cdot R_{total\ in\ input\ circuit}$$

$$= I_i \cdot (R_s \| R_f \| r_\pi)$$

Loading of R_f input side.

Similarly $V_o = -g_m V_\pi (R_f \| R_c)$

loading of R_f output side.

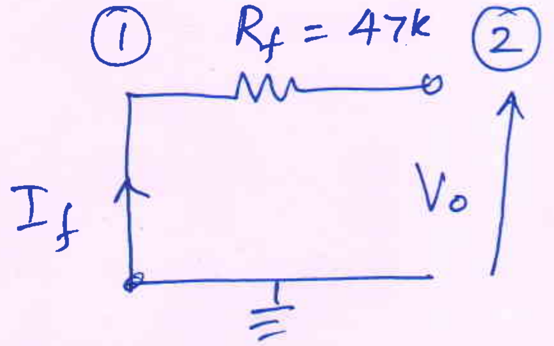
∴ Transresistance

$$A = \frac{V_o}{I_i} = -g_m (R_f \| R_c)(R_s \| R_f \| r_\pi)$$

$$= -60\,m\mho\,(47k \| 4.7k)(10k \| 47k \| 1.667k)$$

$$= 355.48\ K\Omega$$

β network is shown below for β measurement



$$\beta_f = \frac{-I_f}{V_o} = \frac{-V_o/R_f}{V_o} = \frac{-1}{R_f} = \text{Units of Conductance}$$

$$\beta_f = -\frac{1}{47K} \text{ mhos or } A/V$$

∴ Transresistance with Gain A_f

$$A_f = \frac{V_o}{I_s} = \frac{A}{1 + A\beta_f}$$

$$\frac{V_o}{I_s} = \frac{355.4K}{1 + \frac{355.4K}{47K}} = \boxed{-41.511 \; K\Omega}$$

$$\boxed{D = 1 + \frac{355.4K}{47K} = 8.56}$$

Voltage Gain with Feedback.

$$\frac{V_o}{V_s} = \frac{V_o}{I_s \cdot R_s} = (-41.511 K\Omega) \cdot \frac{1}{10k}$$

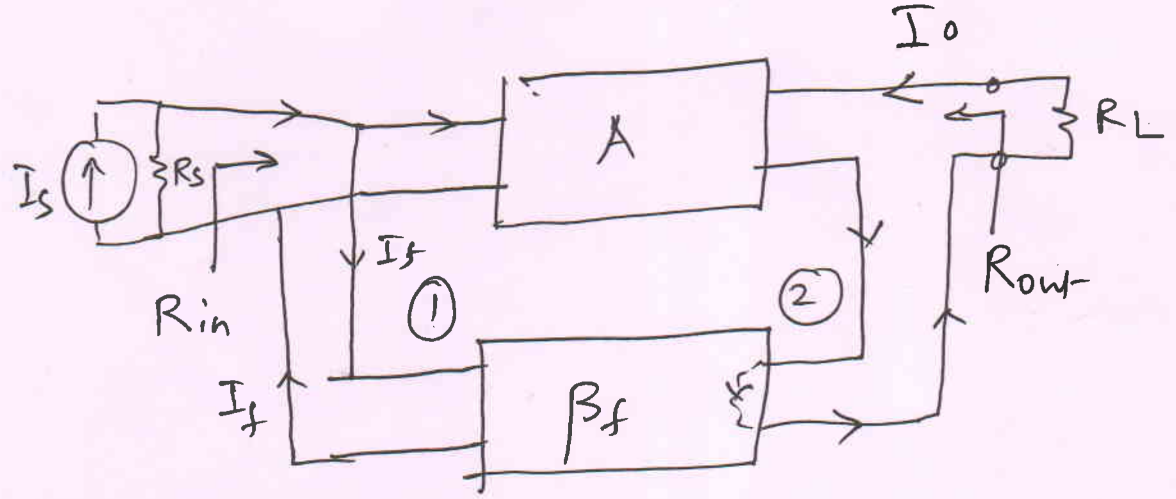
$$= \boxed{-4.1511 \; V/V}$$

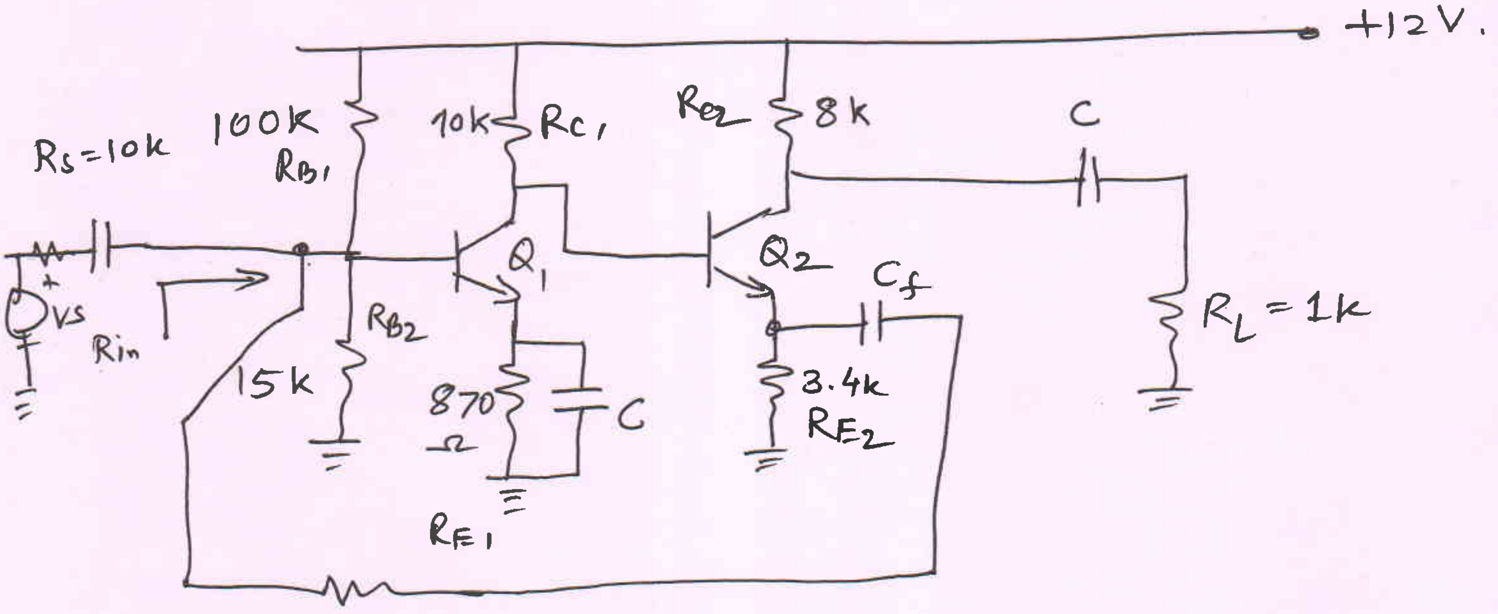
$$\boxed{R_{if} = D\,(R_s // R_\pi) = 166.8\,\Omega}$$

$$R_{of} = \frac{R_o}{D} = \frac{(47K // 4.7K)}{D} = 498\,\Omega$$

SHUNT- SERIES FEEDBACK

~~Voltage~~ CURRENT Sampled inserted in input in Shunt.





Q_1 = first stage 180° phase shift

Q_2 = second stage 0° " " (like emitter Follower)

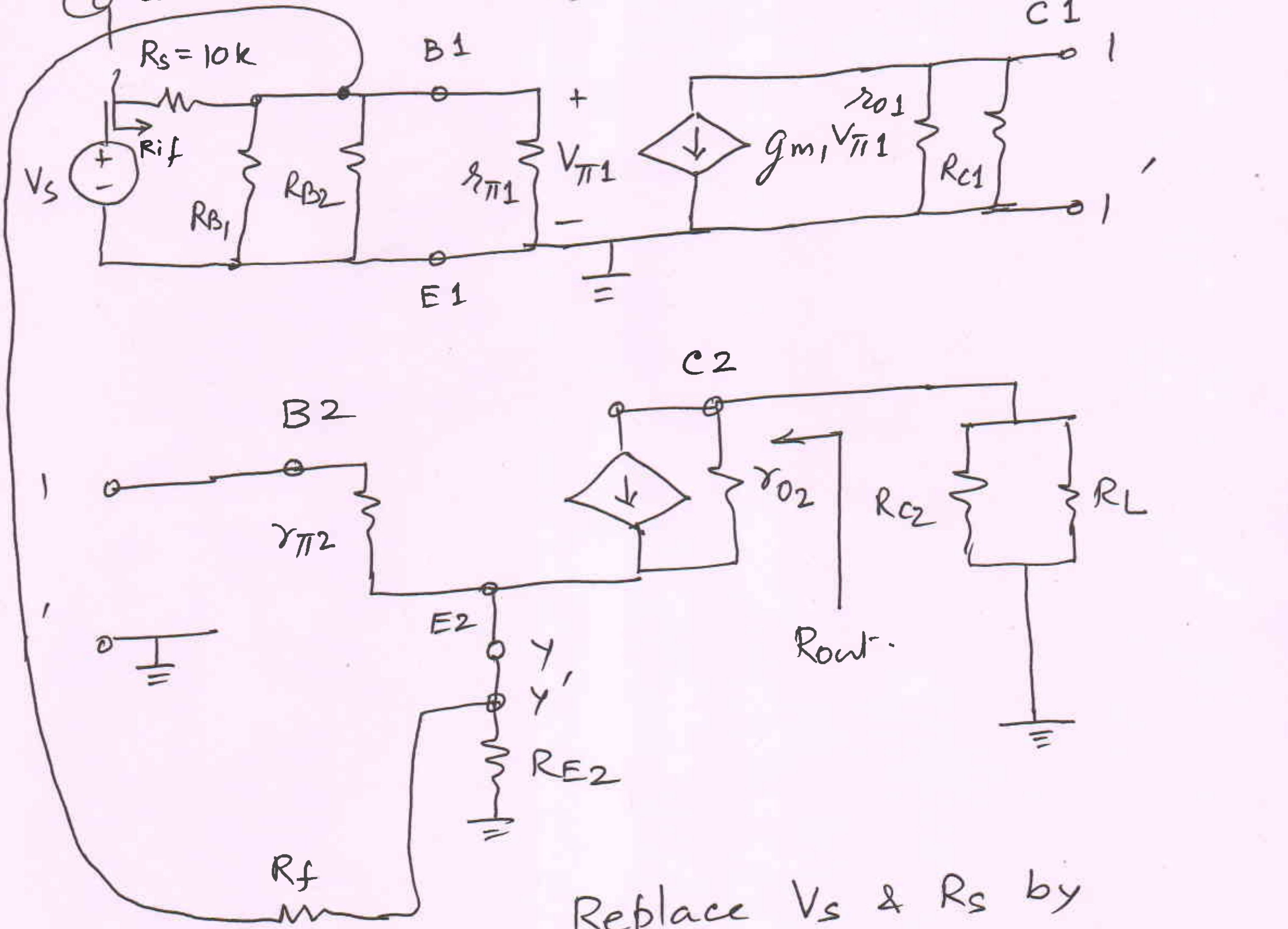
V_f = Output is voltage across R_{E2}

$\therefore V_f \propto$ Output Current.

V_f is inserted in shunt with V_s.

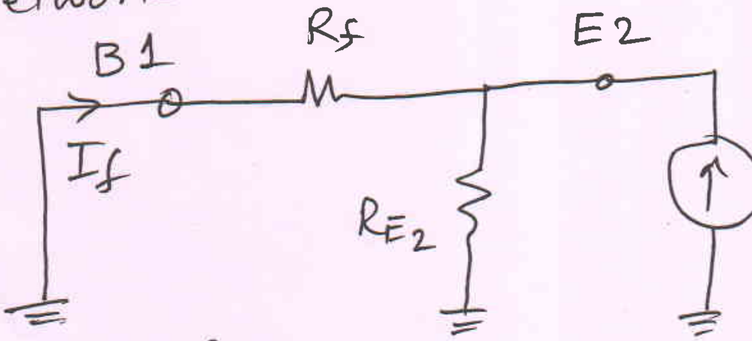
C_f is to isolate DC in both places.

Equivalent small signal model



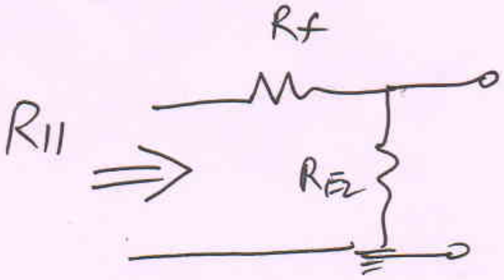
Replace V_s & R_s by Nortor Equivalent.

β_f network looks like

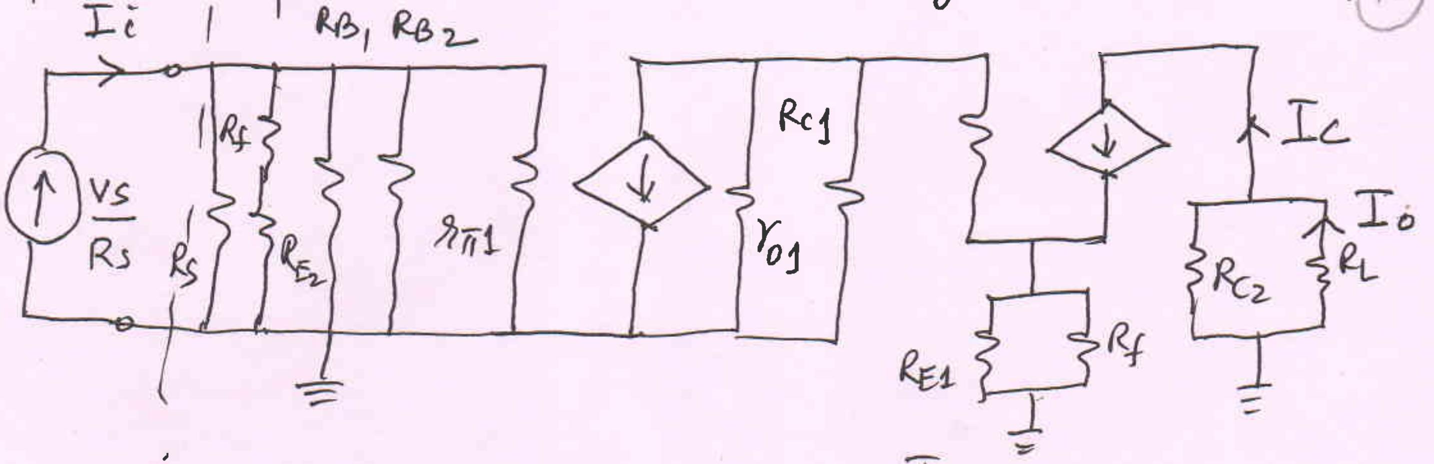


$$\beta_f = \frac{I_f}{I_o}$$

$$\beta_f = -\frac{R_{E2}}{R_{E_2} + R_f}$$



Final Eqv. Circuit for A using loading of β



We have to calculate current gain $A = \dfrac{I_o}{I_i}$

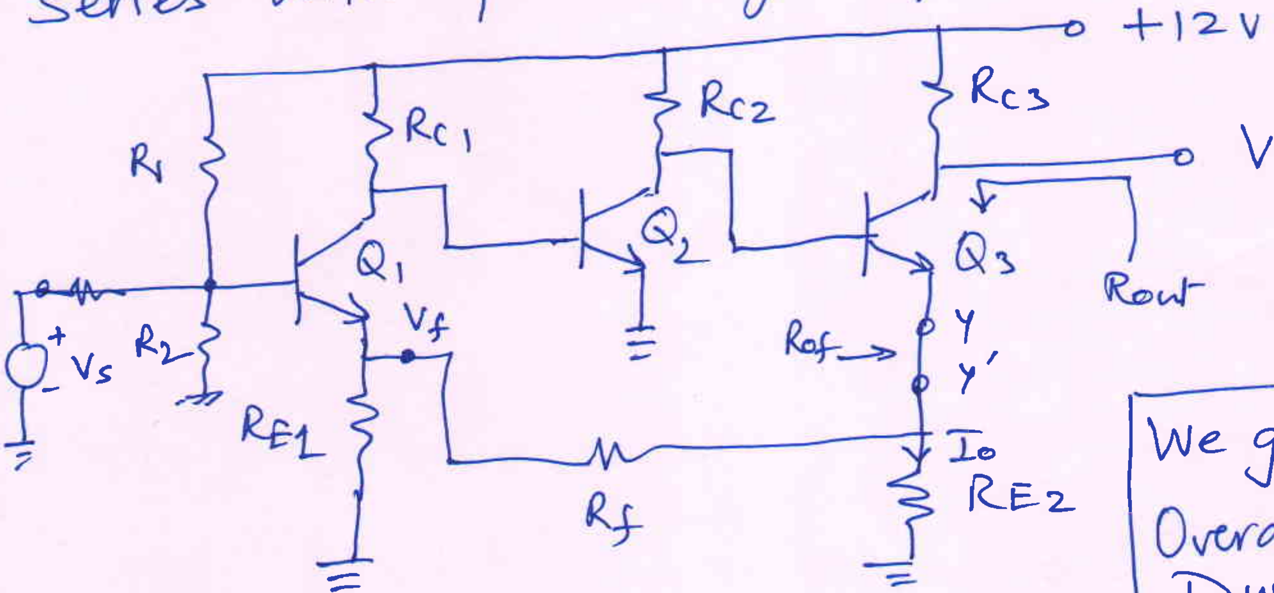
Knowing A & β_f get A_f, R_{if}, R_{of}.

$$R_{if} = \left\{ R_s \,//\, (R_f + R_{E2}) \,//\, R_{B1} \,//\, R_{B2} \,//\, r_{\pi 1} \right\} / D$$

$$R_{of} = \left\{ (R_{E2} \,//\, R_f) + r_{e2} + \frac{R_{C1} // r_{o1}}{\beta + 1} \right\} \times D$$

MULTI-STAGE SERIES SERIES FEEDBACK.

We can use a 3-stage amplifier (CE) and ~~use~~ tap third stage emitter voltage & inject it at first stage emitter. The output current I_o will be sampled and inserted in series with first stage input circuit as V_f



We get large Overall Gain Due to 3 Stages.

$v_{B_1} = V_s$

v_{e_1} = in phase with V_s

v_{c_1} = 180° out of phase with V_s ∴ v_{c_1} = 360° with V_s

v_{c_2} = 180° " " " ∴ v_{c_2} = in phase with V_s

v_{e_2} = in phase with v_{c_2} = in phase with V_s

Note v_{e_1} & v_{e_3} are in phase so v_f strengthens V_s. This is or increases v_{e_1} & opposes more negative effect.