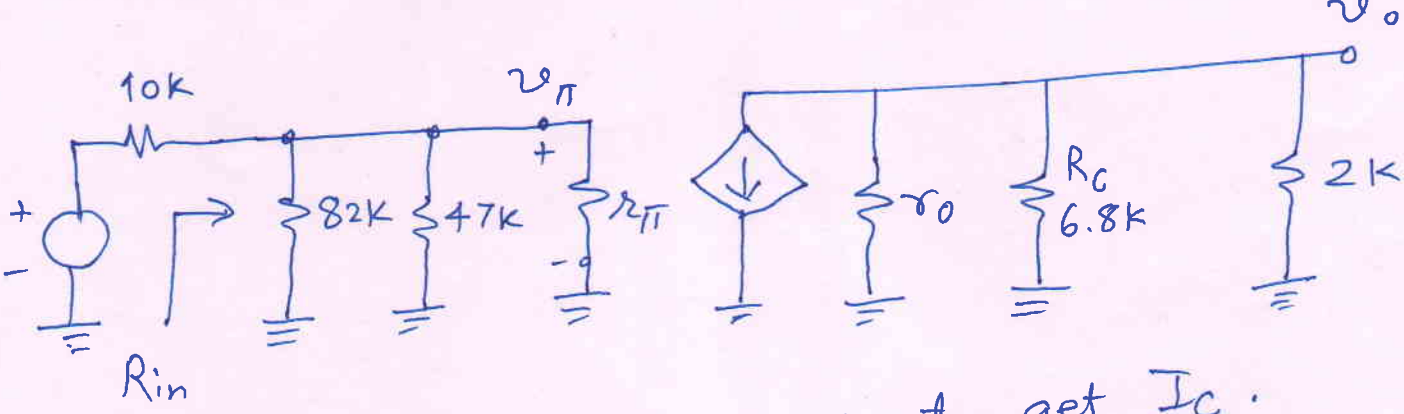
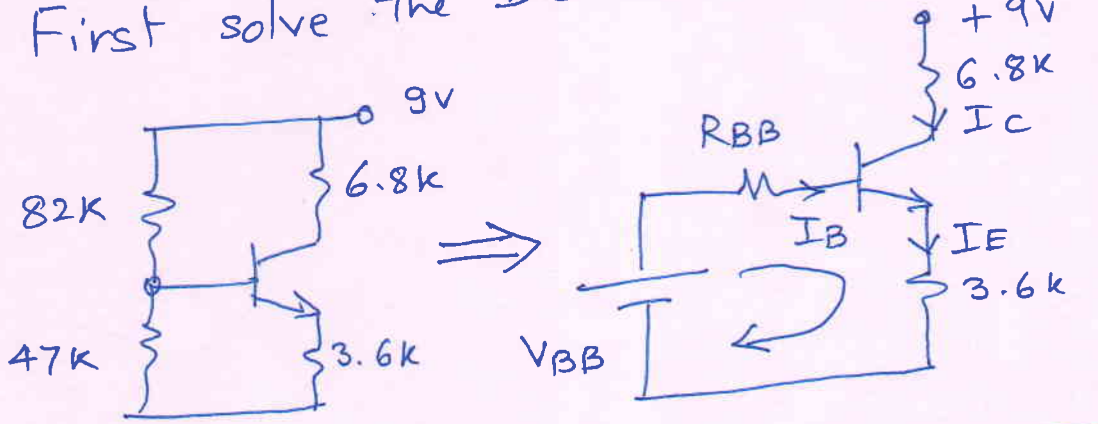
3.132 The original resistor values have been multiplied by 3 to get higher gain. They are

$R_1 = 82K$, $R_2 = 47K$, $R_E = 3.6K$, $R_C = 6.8K$

What is the overall voltage Gain?



First solve the DC currents to get I_C.



$$V_{BB} = \left(\frac{47K}{47K+82K}\right) \cdot 9V = \boxed{3.279\text{ V}}$$

$$R_{BB} = 47K \,||\, 82K = \boxed{29.8K}$$

KVL in Loop.

$3.279V - I_B \cdot 29.8K - 0.7V - (1+100)3.6K \cdot I_B = 0$

$\therefore I_B = 6.55\mu A$ $\quad I_C = 0.655$ mA

Note I_C is now less than 2 mA of first Case.

For $I_C = 0.655\ mA$, Calculate g_m, r_π & r_o (2)

$$g_m = 0.655mA / 25mV = \boxed{26.2\ m\mho}$$

$$r_\pi = \beta / g_m = 100/26.2 = \boxed{3.816\ K\Omega}$$

$$r_o = V_A / I_C = 100/0.655 = \boxed{152.63\ K\Omega}$$

Note that g_m has reduced but other two has increased. That will reduce loading.

$$R_{in} = R_1 \| R_2 \| r_\pi = 47K \| 82K \| 3.816K$$

$$= 3.383K$$

$$v_{be} = \left(\frac{3.383K}{3.383K + 10K}\right) \cdot v_{sig}$$

$$= 0.252 \cdot v_{sig}.$$

Total Collector Resistance $R_{eq} = R_C \| r_o \| R_L$

$$= 6.8K \| 152.63K \| 2K = 1.523K$$

$$v_o = -g_m v_{be} \cdot R_{eq}$$

$$= -26.2m\mho \cdot 1.523K (0.252) v_{sig}$$

$$\therefore \frac{v_o}{v_{sig}} = G_v = -26.2 \times 1.523 \times 0.252$$

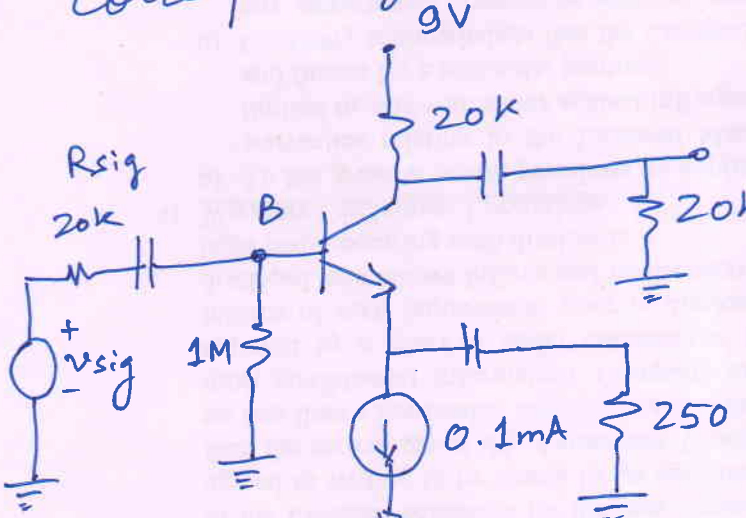
$$= \boxed{-40.08}$$

GAIN HAS INCREASED BY 5 TIMES BY IMPROVING RESISTANCES THOUGH TRANSCONDUCTANCE WAS REDUCED.

3.136 v_{sig} is sinusoidal small signal source. $\beta = 100$. Find R_{in} and G_v. If v_{be} is to be limited to 5 mV, what is the largest signal that can be applied at input? What is the corresponding output voltage of signal?

(4)

pg. 3 not there



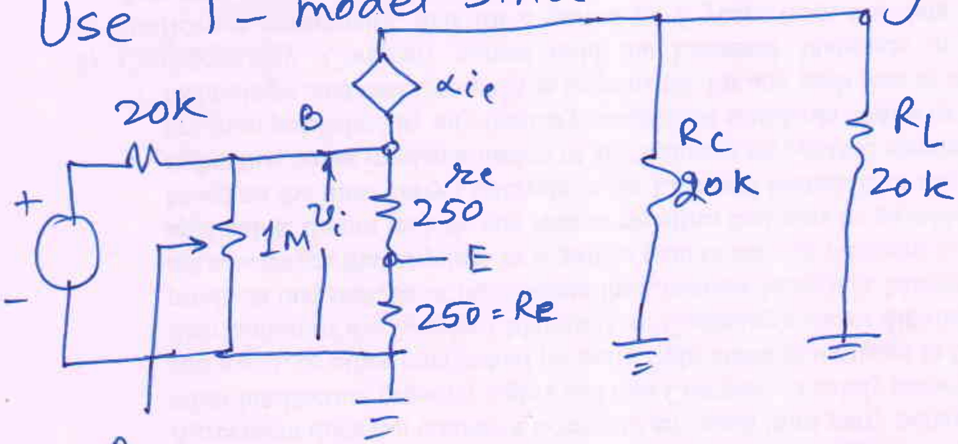
$I_E \simeq I_C = 0.1mA$

$g_m = I_C/V_T = 0.1mA/25mV$

$= \boxed{\frac{1}{250}} = 4\ m\mho$

$r_e = \frac{1}{g_m} = 250\Omega$

Use T-model since emitter is grounded thru 250Ω



Rin

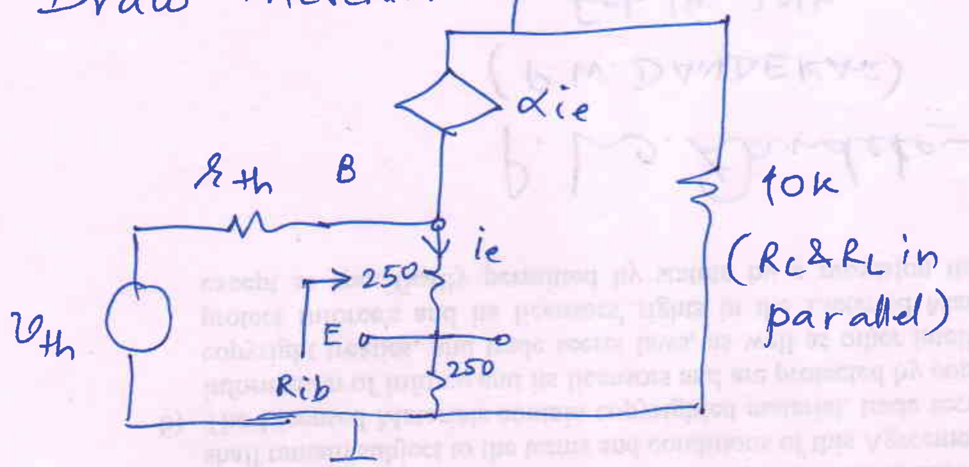
$R_{in} = 1M \| (250+250)(1+\beta)$

$= 1M \| 0.5k \times 101$

$= 1M \| 50.k$

$R_{in} = 1000k \| 50.5k = \boxed{48.07K}$

Draw Thevenin Equivalent Circuit for 5



$$v_{th} = \frac{\cancel{1M+20k}}{\cancel{1}}\left(\frac{1M}{1M+20k}\right) v_{sig} = \frac{\cancel{0.718}}{\cancel{19.6}} \cancel{v_{sig}} = 0.980\, v_{sig}.$$

$$r_{th} = \frac{1M \times 20k}{1M+20k} = 19.607k.$$

$$v_i = \frac{R_{ib}}{R_{ib}+r_{th}} \cdot v_{th}$$

$$= \frac{(250+250)\cdot(1+100)}{(250+250)(1+100)+19.607k} \cdot 0.980\, v_{sig}$$

$$= 0.720 \times 0.980 \times v_{sig}$$

$$= 0.706\, v_{sig}$$

$$i_e = \frac{v_i}{r_e+R_e} = \frac{v_i}{250+250} = \frac{v_i}{0.5k} = 2\cdot v_i \ \text{V/k}\Omega\ \cancel{\text{mA}}$$

$$\cancel{v_i} = \cancel{v_t} = \cancel{\alpha i_e}$$

$$v_o = -\alpha i_e \cdot 10k$$

$$v_o = -\alpha \cdot 10k\,(2 \cdot v_i)\ v/k\Omega$$

$$= -20\ v_i$$

$$= -20 \times 0.706 \times v_{sig}$$

$$\therefore \frac{v_o}{v_{sig}} = -20 \times .706 = \boxed{-14.12}$$

Proper Amplifier's Voltage Gain

$$A_v = \frac{-\alpha\,(R_C \| R_L)}{(R_e + r_e)}$$

$$= -\alpha \frac{(20k \| 20k)}{(250\,\Omega + 250\,\Omega)} = \frac{10k}{500\,\Omega} = \boxed{-20}$$

Note: Amplifier's Voltage Gain -20 has reduced to -14.12 due to loading at input side by a factor 0.706.

$$v_{be} = \frac{r_e}{r_e + R_e} \cdot v_i = \frac{250}{250 + 250} \cdot v_i$$

$$= 0.5\ v_i$$

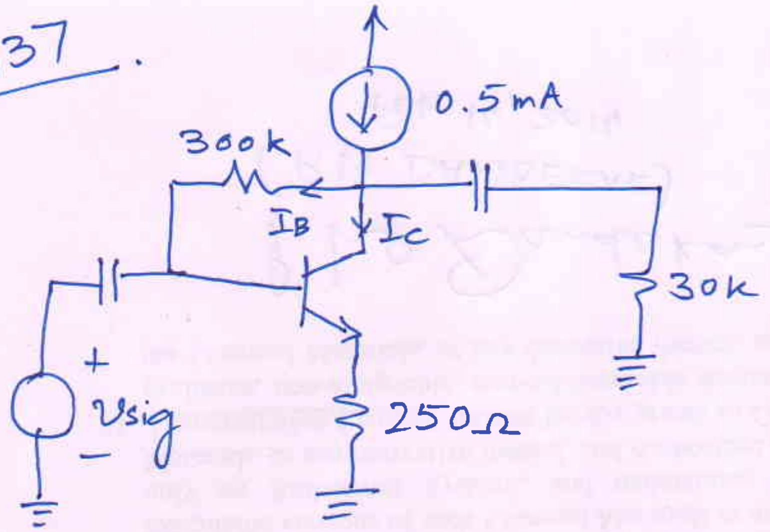
So if max. v_{be} can be 5 mv then max. v_i can be 10 mv. For this $v_o = 10mv(-20) = \boxed{-200\ mv}$

Maximum $v_{sig} = 10mv/0.706 = \boxed{14.16mv}$

P3. 137 Neglect r_o. (7)

$\beta = 100$

$I_C \approx 0.5\,mA$



Find V_C, V_B, V_E

Find I_C

$I_C + I_B = 0.5\,mA = 500\,\mu A$

or $100\,I_B + I_B = 500\,\mu A \quad \therefore I_B = 500/101 = \boxed{4.95\,\mu A}$

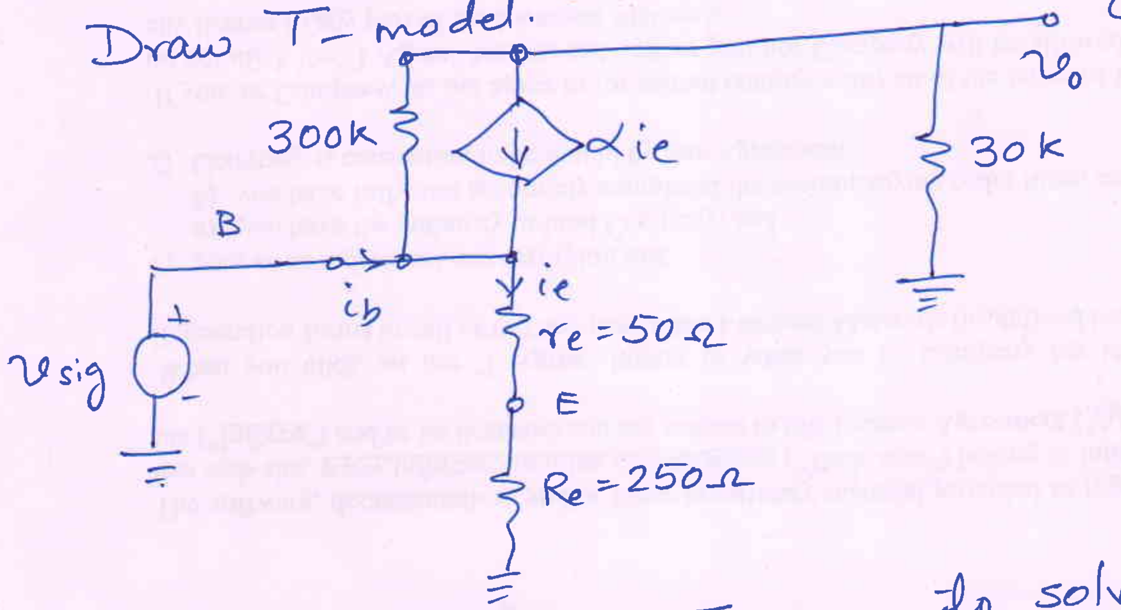
$I_C = 4.95\,\mu A \times 100 = \boxed{495\,\mu A}$.

$\beta = 100$ & $I_C = 0.5\,mA$

$\therefore g_m = 0.5\,mA / 25\,mV = 1/50 = 20\,m℧$

$r_e = \dfrac{1}{g_m} = 50\,\Omega$

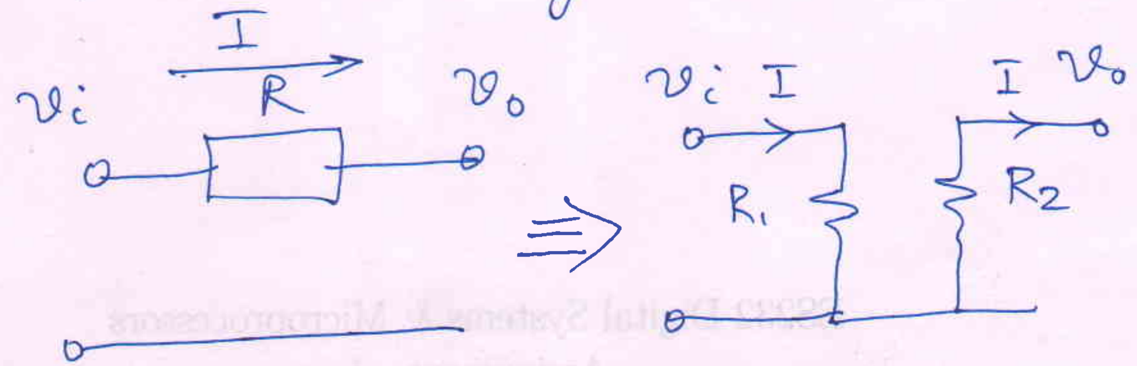
Draw T-model.



There is no RC and no ro.

We will use Miller's Theorem to solve the effect of 300k. It is a Output to input connection so it is called as feedback. Since Output & input is out of phase, it is called negative feedback.

If v_o/v_i can be called as A (voltage Gain) (8)
then miller theorem says that



where $R_1 = R/(1-A)$

and $R_2 = R/\left(1-\frac{1}{A}\right)$

In our case $R = 300k$ Let us first get an estimate of $A = v_o/v_i$ (without 300k connected)

$$A_v = \frac{v_o}{v_i} = -\alpha \frac{(R_C \| R_L)}{r_e + R_e} = \frac{30k}{300\Omega} = \boxed{-100}$$

(without 300k)

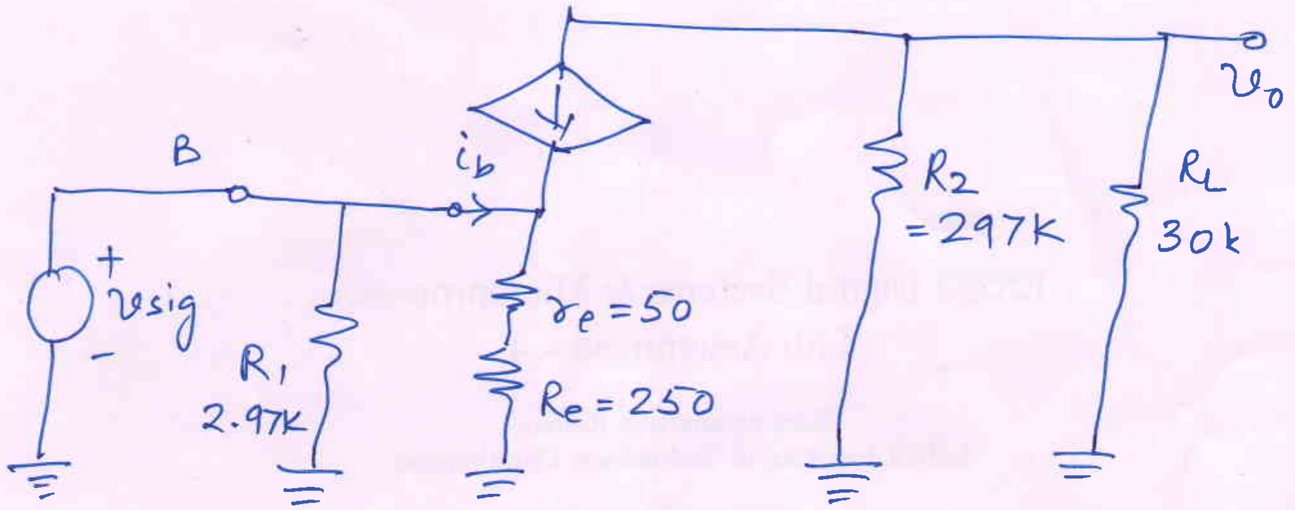
$$\therefore R_1 = \frac{300k}{1-(-100)} = \frac{300k}{101} = 2.97k$$

$$R_2 = \frac{300k}{1-\left(-\frac{1}{100}\right)} = \frac{300k}{1.01} = 297k.$$

We calculate A_v with $R_2 \| R_L$

$$A_v = -\alpha \frac{(297k \| 30k)}{300\Omega} = \boxed{-90.82}$$

T-model with 300K represented by Miller Effect Resistors



Note that there is no effect of 2.97K on G_v because v_{sig} can drive 2.97K as well as base-emitter without any loading because $R_{sig} = 0$.

Note that 300K in shunt $v_o \to v_i$ is equivalent of roughly $\frac{300K}{\beta}$ in parallel with r_π or base-emitter. So a $C \to B$ resistor reduces input resistance drastically and increases attenuation of input signal due to heavy loading. It gets us lot less v_i for a given v_{sig}.

To calculate all Voltages.

(10)

$$I_E = 0.5mA = 500\mu A$$

$$V_E = I_E \cdot R_E = 500\mu A \times 0.25K = \boxed{0.125V}$$

$$V_B = V_E + 0.7 = 0.125 + 0.7 = \boxed{0.825\ V}$$

$$V_C = V_B + I_b \cdot 300k = 0.825 + 5\mu A \times 300K$$
$$= \boxed{2.325\ V}$$