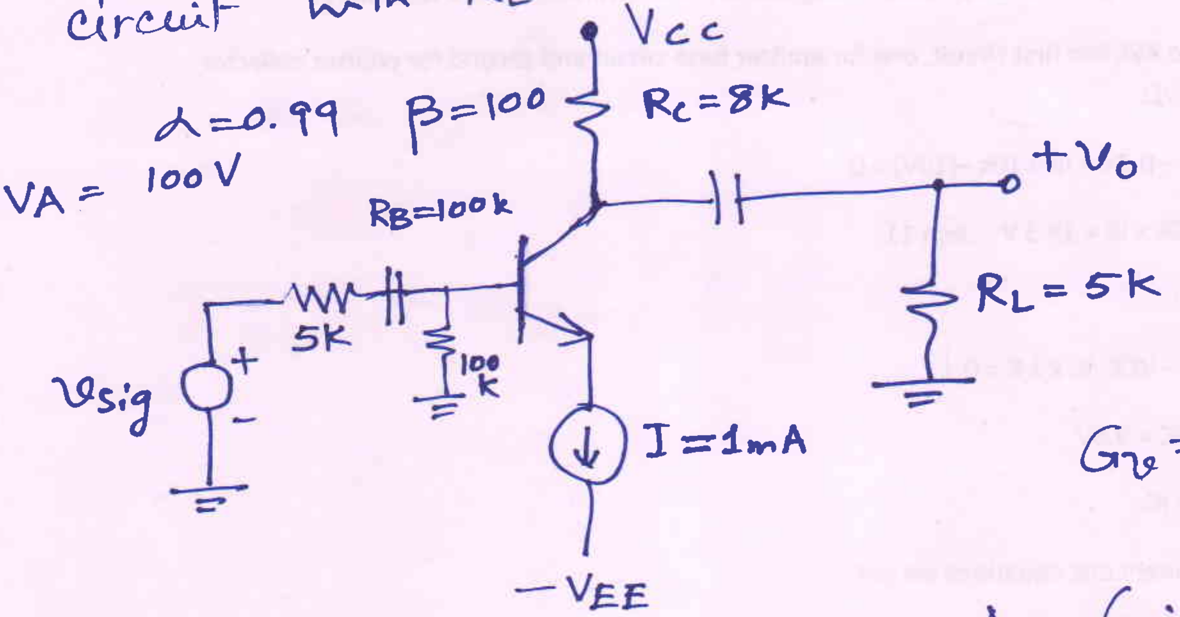
Problem To Be Solved in Class CE Amplifier (1)

Solve for following circuit as well as second circuit with $R_E = 1K$.



$$G_v = \frac{v_o}{v_{sig}}$$

Calculate g_m, r_π, r_o, r_e, R_{in}, A_{vo} (without r_o), ~~Av~~ Gain G_v Overall R_{out} (with and without r_o) and

In second circuit insert a 1K R_E between emitter and current source & recalculate.

— x —

Solution: $I_E = 1mA$ assuming $I_C \approx I_E = 1mA$

$$g_m = I_C/V_T = 1mA/25mV = \boxed{40\,m\mho}$$

$$r_\pi = \beta/g_m = \frac{100}{40\,m\mho} = \boxed{2500\,\Omega}$$

Early Effect resistance $r_o \approx V_A/I_C = \frac{100\,V}{1mA} \approx \boxed{100\,K}$

$$r_e = \frac{1}{g_m} = \frac{1}{40\,m\mho} = \boxed{25\,\Omega}$$ not used here in first part

$$R_{in} = R_B \,||\, R_{iB} = R_B \,||\, r_\pi = 100K \,||\, 2.5K = 2.439\,K$$

Voltage Gain of Amplifier ~~Proper~~

with r_o included and load connected

$$A_{vo} = -g_m (R_C \| R_L \| r_o)$$

$$= -40\,m\mho (8K \| 5K \| 100K)$$

$$= -40\,m\mho (2.985K) = \boxed{-119.4 \ V/V}$$

without r_o included

$$A_{vo} = -40\,m\mho (8K \| 5K) = \boxed{-123.07 \ V/V}$$

Output Impedance/Resistance R_{out} seen by R_L.

$$R_{out} = R_C \| r_o \| = 8K \| 100k = \boxed{7.40K.}$$

Overall Voltage Gain

$$G_v = \left(\frac{R_{in}}{R_{in} + R_{sig}}\right) \cdot g_m \cdot (r_o \| R_C \| R_L)$$

$$= \frac{2.439K}{2.439K + 5K} \cdot 40\,m\mho \cdot (2.985K)$$

$$= 0.327 \cdot (-119.4)$$

$$= \boxed{-39.14 \ V/V}$$

With a emitter resistance $R_E = 1K$ inserted

$g_m = 40 mv$ same as before

$r_\pi = 2500\ \Omega$ " " "

$r_o = 100 K\Omega$ " " "

$$R_{in} = R_B \,\|\, R_{iB} = 100K \,\|\, (r_\pi + (1+\beta) R_E)$$

$$= 100K \,\|\, (2.5K + 101 \cdot 1k)$$

$$= 100K \,\|\, 103.5K \quad = \quad 50.85\,K.$$

(Note R_{in} has improved from $2.43\,K$ to $50.85K$)

Voltage Gain $A_v = -\alpha \dfrac{(R_C \,\|\, R_L)}{r_e + R_E}$

$$= -\alpha \frac{3.076\,K\Omega}{25 + 1K} = -\frac{0.99 \times 3.076\,K}{1.025K}$$

$$= \boxed{-2.971 \quad V/V}$$

(This was -123.07 earlier).

$$\boxed{\begin{array}{l} R_{out} = R_C = 8K \\ \text{or } 7.40K \\ \text{if } r_o \text{ taken into account.} \end{array}}$$

$$G_v = \frac{R_{in}}{R_{in} + R_{sig}} \cdot A_v$$

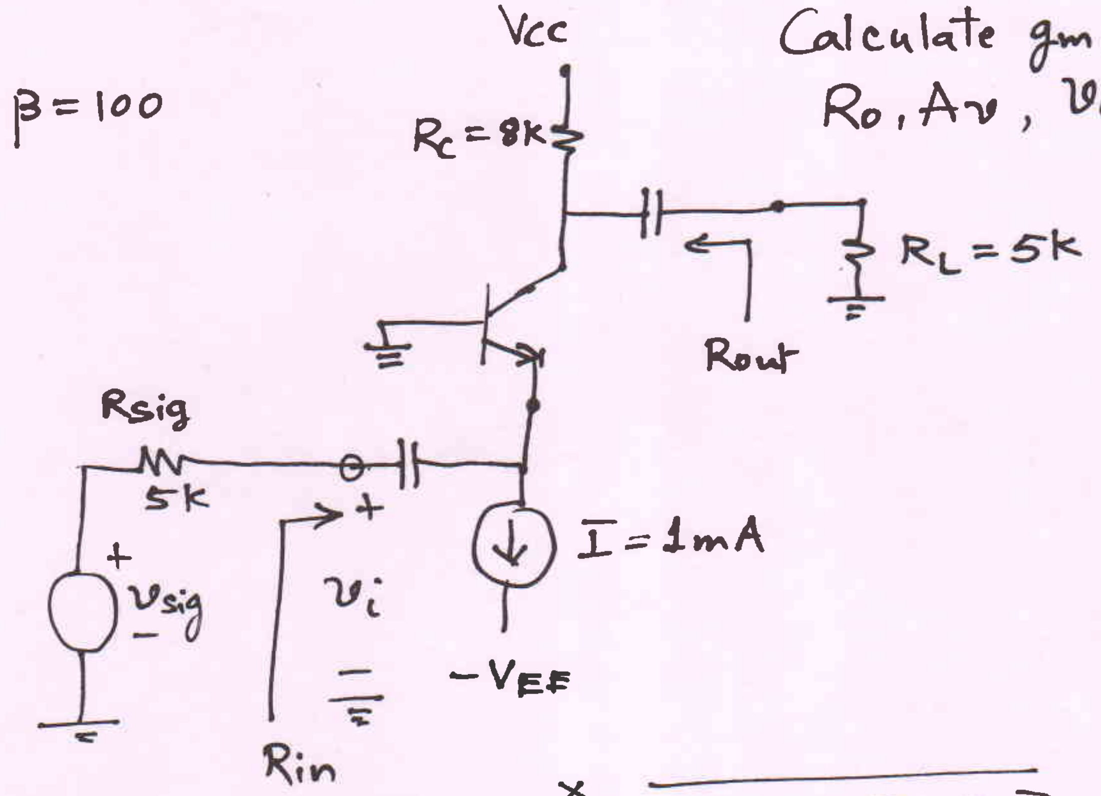
$$= \frac{50.85K}{50.8K + 5K} \cdot (-2.971)$$

$$= 0.910 \times (-2.971) = \boxed{-2.70 \quad V/V}$$

↑ This factor was 0.327, so it is improved.

Problem (4) to be solved in Class on CB Configuration.

Calculate g_m, r_e, R_{in}, A_{vo}
$R_o, A_v, v_i/v_{sig}, G_v$



Soln: $\because I_E = 1mA$ we assume $I_C \approx I_E \simeq 1\,mA$

$\therefore g_m = I_C/V_T = 1mA/25mV = 40\,m\mho$

$r_e = \frac{1}{g_m} = \frac{1}{40\,m\mho} = 25\,\Omega$

Signal source sees a very low input resistance

$R_{in} = r_e = 25\,\Omega$

$$\frac{v_i}{v_{sig}} = \frac{r_e}{r_e + R_{sig}} = \frac{25}{25 + 5K} = \frac{25}{5.02K} = \frac{1}{201}$$
$$= 0.004975$$

$$A_{vo} = \frac{\alpha R_C}{r_e} = \frac{.99 \times 8K}{25\,\Omega} = \boxed{316.8\ V/V}$$
(Note +ve sign)

$$\underset{\text{(with load)}}{A_v} = \frac{\alpha(R_C \| R_L)}{r_e} = \frac{.99}{25}(3.0769K) = \boxed{121.84}\ V/V$$

$$R_{out} = R_C = 8K\Omega$$

$$A_{is} = \frac{-\alpha i_e}{i_i} = -\frac{\alpha i_e}{-i_e} = \alpha = 0.99$$

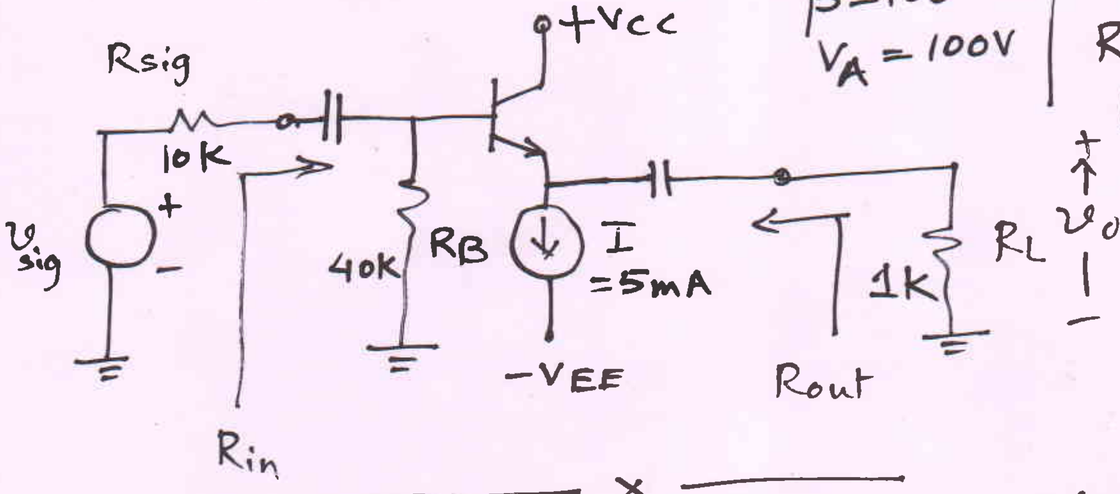
$$G_v = \left(\frac{v_i}{v_{sig}}\right) \times A_v$$

$$= \frac{1}{201} \times 121.84$$

$$= \boxed{0.606 \text{ V/V}}$$

Note that due to input impedance mismatch so much signal is lost in R_{sig} that overall voltage Gain < 1. So we are better off without an amplifier since this amplifier gain < 1 or it is an attenuator.

Problem to be solved in Class about CC Configuration
(Emitter Follower)



$\beta = 100$
$V_A = 100V$

Find g_m, r_π, R_{ib}, R_{in}, G_v, G_{vo}, R_{out}

Change in G_v if $R_L = 2K$ or $0.5K$?

$I_E = 5mA \quad I_C = 5mA \times .99 = 4.95mA$

$g_m = I_C/V_T = 4.95\,mA/25mV = 198\ mv$

$r_e = \frac{1}{g_m} = 5.05\Omega$

$R_{ib} = (1+\beta)\left[r_e + r_o \| R_L\right]$

$r_o = V_A/I_C \approx 100/4.95 = \boxed{20.2K}$

$\therefore\ R_{ib} = (101)\left[5\Omega + 20.2K \| 1K\right]$

$= 101\,[957.8] = \boxed{96.741\ K}$

(Note Such a high Rib).

$R_{in} = R_b \| R_{ib} = 40K \| 96.741K = \boxed{28.29K}$

$$G_v = \left(\frac{R_B}{R_{sig}+R_B}\right)\cdot \frac{(r_o \| R_L)}{\frac{(R_{sig}\|R_B)}{\beta+1} + r_e + (r_o \| R_L)}$$

$$= (0.8)\,\frac{0.952K}{\frac{32K}{101} + 5\Omega + 0.952K}$$

$$= 0.8 \frac{0.952K}{0.316K + 0.005K + 0.952K}$$

$$= 0.8 \times \frac{0.952K}{1.274K}$$

$$G_v = \boxed{0.598 \ V/V} \quad \text{For } R_L = 1K$$

G_{vo} is overall voltage Gain when $R_L = \infty$

$$G_{vo} = \left(\frac{R_B}{R_{sig} + R_B}\right)\left(\frac{r_o}{\left(\frac{R_{sig} \| R_B}{1+\beta}\right) + r_e + r_o}\right)$$

$$= 0.8 \frac{20.2K}{\frac{32K}{101} + 5\Omega + 20.2K}$$

$$= 0.8 \frac{20.2K}{0.316K + 0.005K + 20.2K} = 0.8 \times \frac{20.2K}{20.5K}$$

$$\boxed{G_{vo} = 0.788 \ V/V}$$

Resistance seen from output R_{out}

$$R_{out} = r_o \| \left(r_e + \frac{R_{sig} \| R_B}{\beta + 1}\right)$$

$$= 20.2k \| \left(5\Omega + \frac{8K}{101}\right) = 20.2K \| 84.2$$

$$= \boxed{83.85\Omega}$$