Faculty of Engineering
Benha university
Electrical Eng.Dept.
Dr Hossam Labib Zayed

Electronic Circuits (b) (E1204)
Final-Term Exam (corrective)
Date: 22/5/2016
Time: 3 Hours

Answer the following questions:

Q1:(a) The JFET in the circuit of fig.(1) has $V_p = -3V$, $I_{DSS} = 9mA$ and $\lambda = 0$. Find the values of all resistors so that $V_G = 5V$, $I_D = 4$ mA and $V_D = 11V$. Design for 0.05 mA in the voltage divider.

(b) Find V_o/V_s for the network shown in fig.(2) if both op amps are considered to be ideal.

Q2: The NMOS transistor in the amplifier circuit shown in fig.(3) has V_t= 1 V and K_n=1mA/V^2, and V_A=100V.

(a) Determine the I_D, V_{GS}, V_D, g_m and r_o.

(b) Determine R_{in}, R_{out}, and the overall voltage gain.

Q3: Consider the common gate amplifier shown in fig.(4) with transistor parameter g_m = 2mA/V. If I = 1mA, $V_{DD} = V_{SS}$ = 5V, R_G = 1 MΩ, $R_D = R_L$= 3kΩ using T-model determine the small signal voltage gain $A_v = (v_o/v_i)$, the input resistance R_{in}, and the output resistance R_{out}.

Q4: The two op amps in the circuit shown in fig.(5) are ideal. Find v_o, i_x and i_o.

Q5: Find the voltage gain v_o/v_i and the differential input resistance of the amplifier shown in fig. (6). Assuming $\beta = 100$.

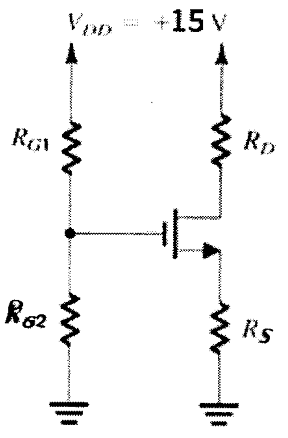


Fig.(1)

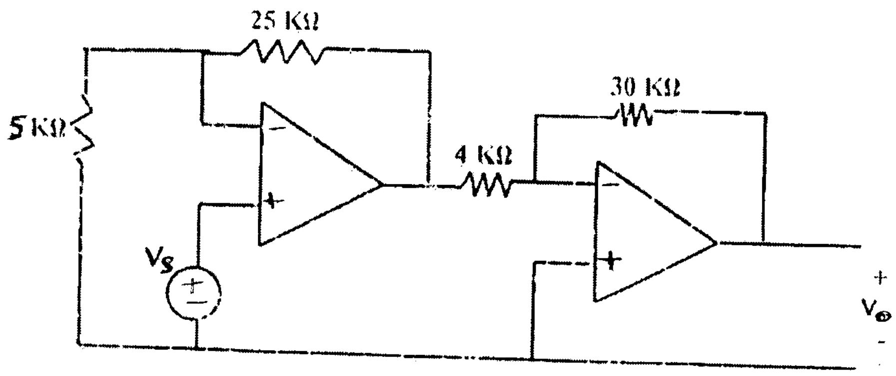


Fig.(2)

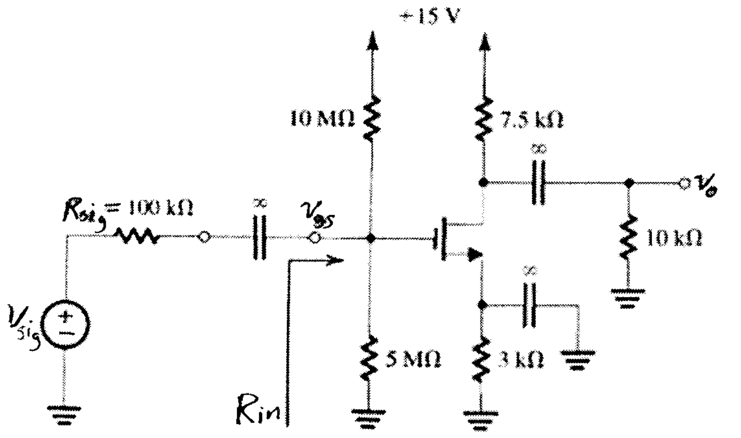


Fig.(3)

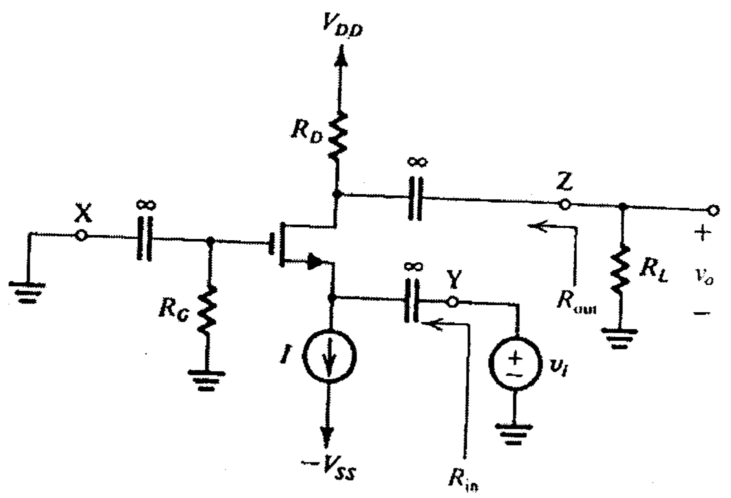


Fig.(4)

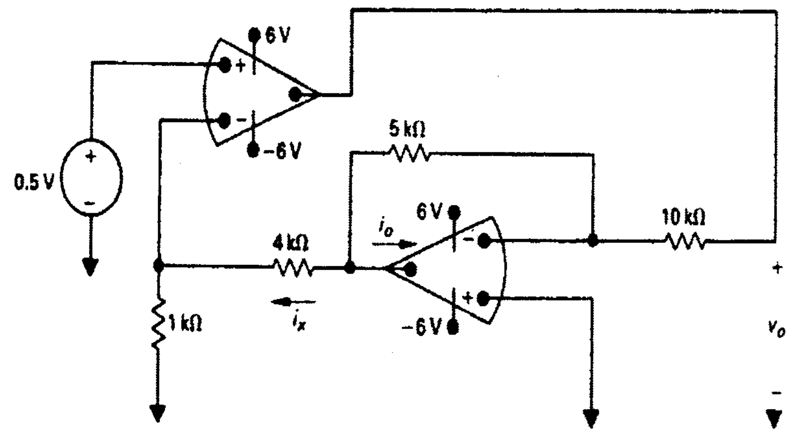


Fig.(5)

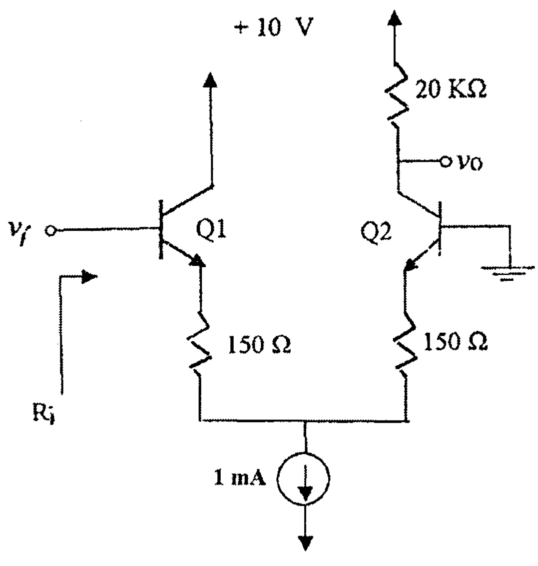
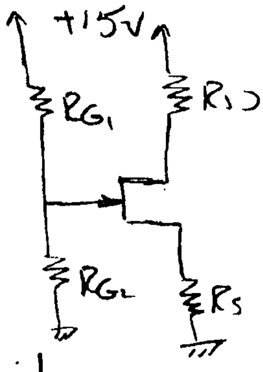


Fig.(6)

BEST WISHES

Hossam Labib

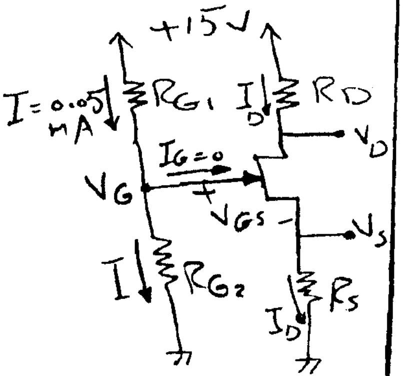
Q (a) The JFET in the circuit shown has $V_p = -3\ V$, $I_{DSS} = 9\ mA$ and $\lambda = 0$. Find the values of all resistors so that $V_G = 5\ V$, $I_D = 4\ mA$ and $V_D = 11\ V$, Design for 0.05 mA in the voltage divider.



Solution

$\because I_G = 0$ & $V_G = 5V$

$R_{G1} = \dfrac{15-5}{0.05mA} = 200\ K\Omega.$



$R_{G2} = \dfrac{5-0}{0.05mA} = 100K\Omega.$

$R_D = \dfrac{15-V_D}{I_D} = \dfrac{15-11}{4m} = 1K\Omega.$

$V_{DS}|_{sat} = V_{GS} - V_p = V_G - V_S - V_P = 5 - V_S + 3$
$= 8 - V_S$

$V_{DS} = V_D - V_S = 11 - V_S$

$\because V_{DS} > V_{DS}|_{sat}$ $\therefore$ Tr. In saturation region

$\therefore I_D = I_{DSS}(1 - \dfrac{V_{GS}}{V_p})^2$

$4\ mA = 9\ mA(1 + \dfrac{V_{GS}}{3})^2 \Rightarrow \dfrac{4}{9} = (1 + \dfrac{V_{GS}}{3})^2$

$\pm\dfrac{2}{3} = (1 + \dfrac{V_{GS}}{3}) \overset{\times 3}{\Rightarrow} \pm 2 = 3 + V_{GS}$

$V_{GS} = \pm 2 - 3 \Rightarrow V_{GS} = -1$ & $V_{GS} = -5$

for $V_{GS} = -5V < V_p \Rightarrow$ neglected

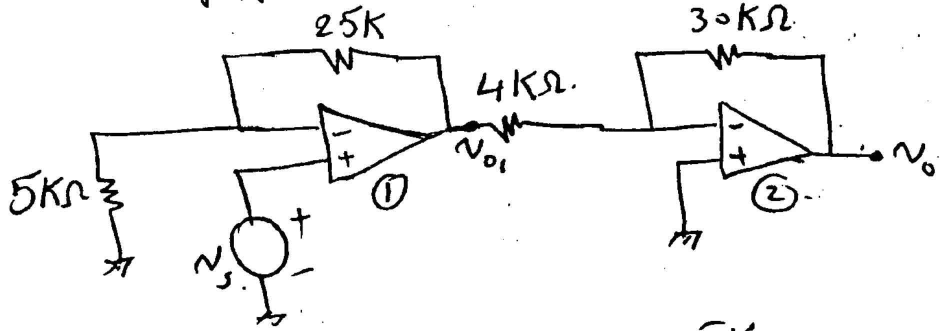
Then $V_{GS} = -1\ V$

$\because V_{GS} = V_G - V_S \Rightarrow V_S = V_G - V_{GS} = 5 + 1 = 6V$

$\therefore R_S = \dfrac{V_S}{I_D} = \dfrac{6}{4m} = 1.5\ K\Omega.$

Q1(b)

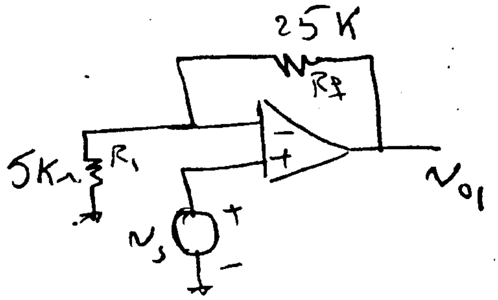
Find $\frac{v_o}{v_s}$ for ideal op Amps



Solution

For op Amp ①

∵ non inverting op Amp.



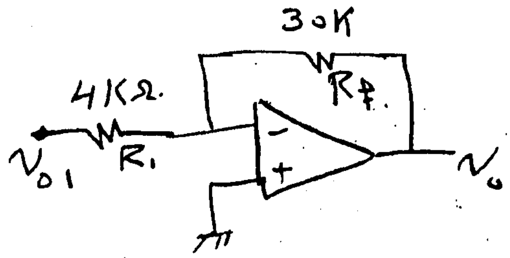
$$\therefore v_{o1} = \left(1 + \frac{R_f}{R_1}\right) v_s$$

$$v_{o1} = \left(1 + \frac{25K}{5K}\right) v_s = (1+5)\, v_s$$

$$v_{o1} = 6\, v_s$$

for op Amp ②

∵ Inverting op Amp.



$$v_o = \frac{-R_f}{R_1} v_{o1}$$

$$v_o = \frac{-30K}{4K} v_{o1} = -7.5\, v_{o1}$$

$$v_o = -7.5 \times 6\, v_s = -45\, v_s$$

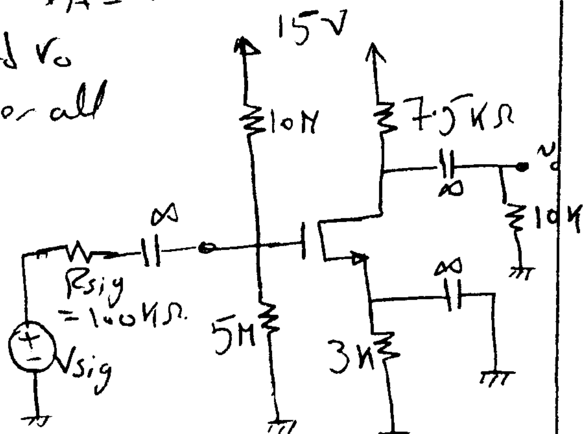
$$\frac{v_o}{v_s} = -45$$

Q2: (points)

The NMOS Transistor in the amplifier circuit shown in Fig.( ) has $V_t = 1V$, $K_n = 1\ mA/V^2$, and $V_A = 100V$

(a) Determine I_D, V_{GS}, V_D, g_m and r_o

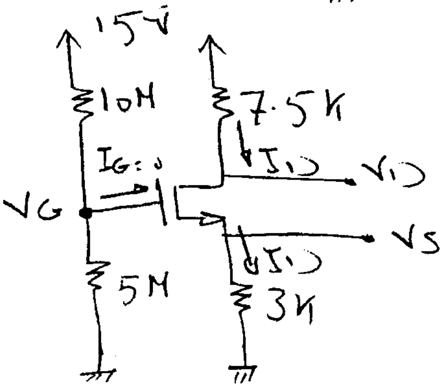
(b) Determine R_{in}, R_{out}, and The over all Voltage gain



solution

DC Analysis

- All capacitor are o.c
- reduce AC sources



$$V_G = \frac{15 * 5M}{10M + 5M} = 5\ V$$

$$V_S = 3 * I_D = 3 I_D$$

$$V_{GS} = V_G - V_S = 5 - 3 I_D$$

$$\therefore I_D = K_n (V_{GS} - V_t)^2$$

$$= 1(5 - 3I_D - 1)^2$$

$$I_D = (4 - 3I_D)^2$$

$$I_D = (16 - 24 I_D + 9 I_D^2)$$

$$9 I_D^2 - 25 I_D + 16 = 0$$

$$(9I_D - 16)(I_D - 1) = 0$$

$\Rightarrow I_D = \frac{16}{9} = 1.778\ mA$; $I_D = 1\ mA$

for $I_D = 1.778\ mA \Rightarrow V_{GS} = 5 - 3 * 1.778 = -0.33\ V < V_t$ X

for $I_D = 1\ mA \Rightarrow V_{GS} = 5 - 3*1 = 2\ V > V_t$ ✓

$\therefore I_D = 1\ mA$

; $V_{GS} = 2V$

$$V_D = 15 - I_D * 7.5 = 15 - 1 * 7.5 = 7.5\ V$$

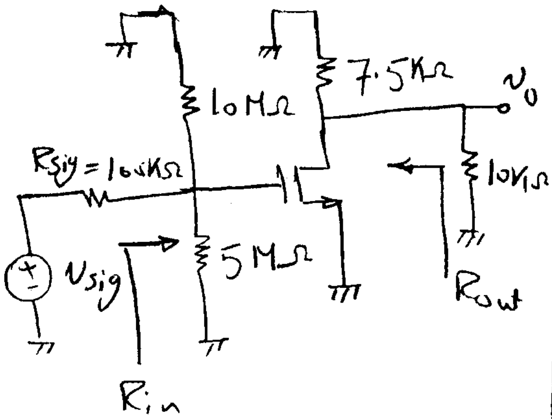
$$g_m = 2 K_n (V_{GS} - V_t) = 2 * 1(2 - 1) = 2\ mA/V$$

$$r_o = \frac{V_A}{I_D} = \frac{100}{1mA} = 100k\ \Omega.$$

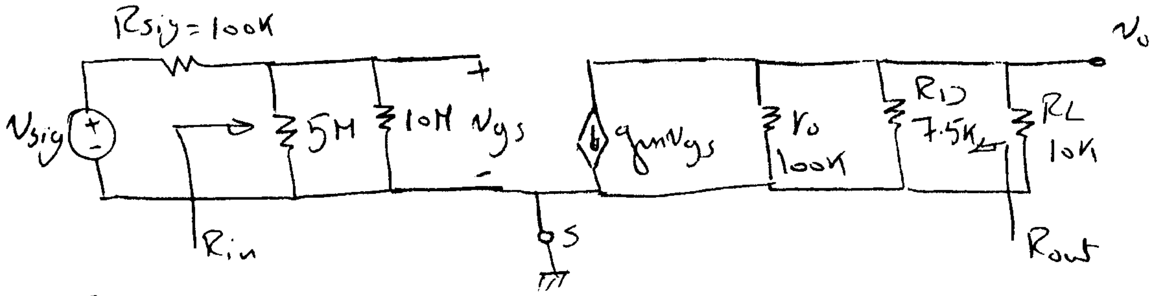
Q2: cont.

AC Analysis

- All capacitors are s.c
- reduce DC sources



Using π. Mode



$R_{in} = 5M \parallel 10M = 3.333\ M\Omega.$

$R_{out}\big|_{v_{sig}=0} = r_o \parallel R_D = 100K \parallel 7.5K = 6.98\ K\Omega.$

$v_o = -g_m v_{gs} (r_o \parallel R_D \parallel R_L)$

$v_{gs} = v_{sig} \dfrac{R_{in}}{R_{in}+R_{sig}}$

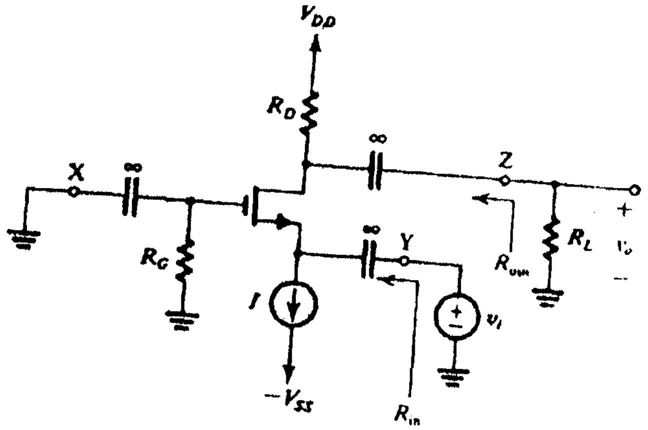
$v_o = -g_m v_{sig} \dfrac{R_{in}}{R_{in}+R_{sig}} (r_o \parallel R_D \parallel R_L)$

$\therefore A_v = \dfrac{v_o}{v_{sig}} = -g_m \dfrac{R_{in}}{R_{in}+R_{sig}} (r_o \parallel R_D \parallel R_L)$

$= -2 \times 10^{-3} \dfrac{3.333 \times 10^6}{3.333 \times 10^6 + 100K} (100K \parallel 7.5 \parallel 10K)$

$= -2 \times 10^{-3} * 0.971 * 4.11K = -7.98\ V/V$

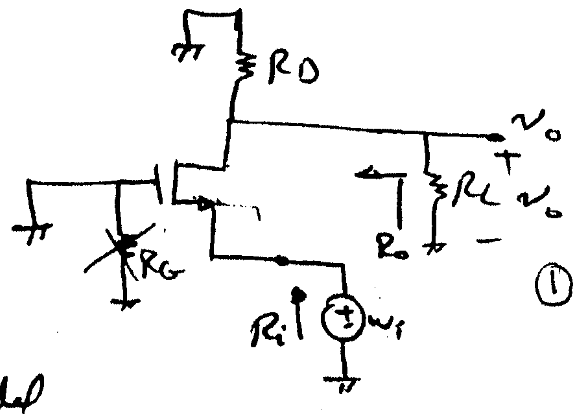
Q3: Consider the common gate amplifier shown in fig. (4) with transistor parameter $g_m = 2mA/V$. If $I = 1mA$, $V_{DD} = V_{SS} = 5V$, $R_G = 1\ M\Omega$, $R_D = R_L = 3k\Omega$ using T-model determine the small signal voltage gain $A_v = (v_o/v_i)$, the input resistance R_{in}, and the output resistance R_{out}.



Solution

$g_m = 2\,mA/V$

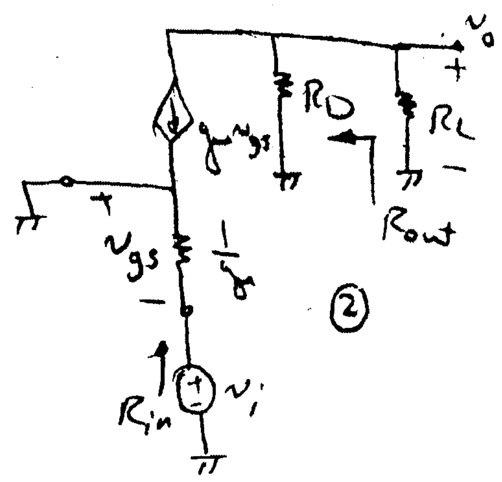
AC Analysis



Using T-model

$R_i = \frac{1}{g_m} = \frac{1}{2\times10^{-3}} = 0.5\ K\Omega$ → ②

$R_o\big|_{v_i=0} = R_D = 3\ K\Omega$ → ②



$v_o = -g_m v_{gs}(R_D \parallel R_L)$ → ①

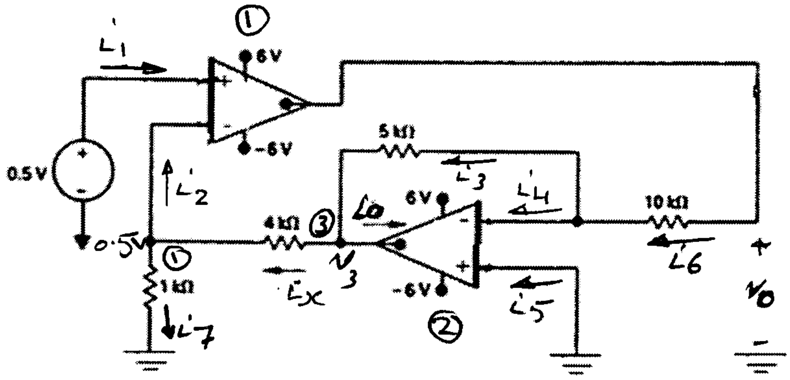
$v_{gs} = -v_i$ → ①

$v_o = +g_m v_i (R_D \parallel R_L)$

$A_v = \frac{v_o}{v_i} = g_m (R_D \parallel R_L)$ → ①

$= 2\times10^{-3} (3K \parallel 3K) = 3\ V/V$ → ②

Q4) The two op amps in the circuit shown in fig.(5) are ideal. Find v_o, i_x and i_o.



Solution:

For op Amp ① $\Rightarrow v_1^+ = v_1^- = 0.5\ V$

$i_1 = i_2 = 0$

at node ①

$i_2 + i_7 = i_x$; $i_2 = 0$

$i_x = i_7 \Rightarrow i_x = \dfrac{0.5}{1K} = 0.5\ mA$

For op Amp ② $\Rightarrow v_2^+ = v_2^- = 0$; $i_4 = i_5 = 0$

at node ②

$i_6 = i_3 + i_4$; $i_4 = 0$

$i_6 = i_3 \Rightarrow \dfrac{v_o - v_2^-}{10K} = \dfrac{v_2^- - v_3}{5K} \Rightarrow \dfrac{v_o}{10K} = \dfrac{-v_3}{5K}$ $*5K$

$0.5\, v_o = -v_3 \Rightarrow v_o = -2 v_3 \longrightarrow$ (1)

$\because v_3 = i_x * 4K + 0.5V = 0.5m \times 4K + 0.5 = 2.5\ V$

$v_o = -2 * 2.5 = -5V \Rightarrow v_o = -5V$

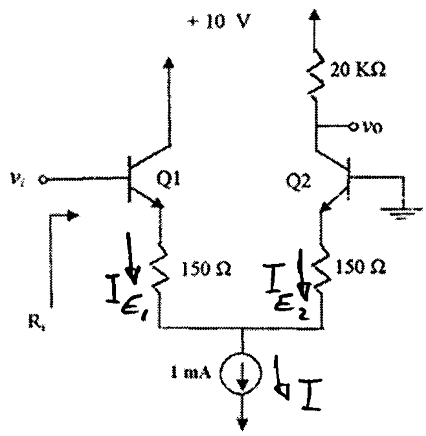
at node ③

$i_3 = i_o + i_x \Rightarrow i_o = i_3 - i_x$

$i_o = \dfrac{-v_3}{5K} - 0.5m = \dfrac{-2.5}{5K} - 0.5m = -0.5m - 0.5m$

$i_o = -1\ mA$

Q5) Find the voltage gain and the input resistance of the amplifier shown in fig.(6) assuming that $\beta = 100$.



Solution:

Dc Analysis

$\because I_{E_1} = I_{E_2} = I_E = \frac{I}{2}$

$\therefore I_E = \frac{1mA}{2} = 0.5\ mA$

$I_C = \alpha I_E = 0.99\, I_E$

$= 0.99 \times 0.5mA = 0.494\ mA \simeq 0.5\ mA$

$r_e = \frac{V_T}{I_E} = \frac{25mV}{0.5mA} = 50\,\Omega$

$g_m = \frac{I_C}{V_T} = \frac{0.5mA}{25mV} = 20\ mA/V$

Ac Analysis

Voltage gain $\left|\frac{v_o}{v_i}\right| = \left|\frac{R_C}{2r_e + 2R_E}\right|$

$= \frac{20K}{2(50+150)} = 50\ V/V$

$R_i = (1+\beta)(2r_e + 2R_E)$

$= 2(1+\beta)(r_e + R_E)$

$= 2(1+100)(50+150) = 40.4\ K\Omega.$