-Harsha Vardhan

-Home Assignment - 1 (24EC1204)

2400040454

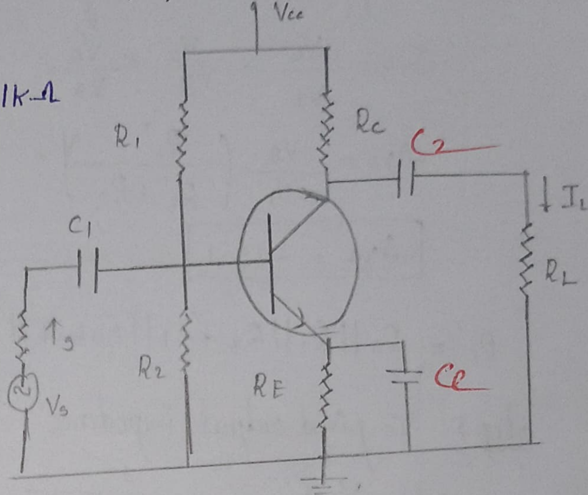
1) using the given parameter for single state CE amplifier with $R_s = 1k\Omega$, $R_1 = 50k\Omega$ $R_2 = 2k\Omega$, $R_c = 1k\Omega$, $R_L = 1.2k\Omega$, $h_{fe} = -50$, $h_{ie} = 1.1k\Omega$, $h_{oe} = 25\mu A/v$ & $h_{re} = 2.5\times10^{-4}$. Develop the Complete h-parameter small-signal model, perform the necessary Circuit analysis, then determine $A_i, R_i, A_v, A_{is}, A_{vs}, R_o$?

Sol: Given data;

$R_s = 1k\Omega$, $R_1 = 50k\Omega$, $R_2 = 2k\Omega$, $R_c = 1k\Omega$

$R_L = 1.2k\Omega$ $h_{fe} = 50$ $h_{ie} = 1.1k\Omega$

$h_{oe} = 25\times10^{-6}$ $h_{re} = 2.5\times10^{-4}$



step1: To find Current gain A_I?

$$A_I = \frac{-h_{fe}}{1 + h_{oe} R_L'} \longrightarrow (1)$$

here $R_L' = (R_c \| R_L) = \frac{1\times10^3 \times 1.2\times10^3}{(1+1.2)\times10^3} = 0.545k\Omega$

$$= \frac{-50}{1 + (25\times10^{-6})(545)}$$

$$\boxed{A_I = -49.33}$$

step2: Input resistence R_i?

$$R_i = h_{ie} + h_{re} A_I R_L'$$

$$= 1.1\times10^3 + 2.5\times10^{-4}(-49.33)(545)$$

$$= 3.6\times10^{-1} * (-49.32)(545)$$

$$\boxed{R_i = 1093\Omega}$$

step3: Voltage gain A_v?

$$A_v = \frac{V_2}{V_1} = \frac{A_I R_L'}{R_i}$$

$$= \frac{-49.33\times545}{1093}$$

$$\boxed{A_v = -24.61}$$

step4: To find A_{is}

$$A_{is} = A_i \frac{R_1 \| R_2}{R_1 \| R_2 + R_i} \longrightarrow (1)$$

$R_1 \| R_2 = 1.923k\Omega$

$$= -49.33 \times \frac{1.923\times10^3}{1.923\times10^3 + 1.09\times10^3}$$

$$= -49.33 \times \frac{1.923}{3.013}$$

$$\boxed{A_{is} = -31.49}$$

10/10

step 6: To find Voltage gain A_v?

$$A_v = \frac{V_c}{V_B} = \frac{A_i R_L'}{R_i} = \frac{-49.32 \times 545.45}{1093} = -24.61$$

step 7: To find Source Voltage A_{vs}

$$A_{vs} = \frac{V_c}{V_s} = \frac{V_c}{V_B} \times \frac{V_B}{V_s}$$

$$A_{vs} = \frac{V_2}{V_1}\left(\frac{R_L'}{R_L' + R_s}\right) = A_v\left(\frac{R_i'}{R_i' + R_s}\right) = 24.61\left(\frac{696.9}{10^3 + 696.9}\right)$$

$$\boxed{A_{vs} = -10.1}$$

$$R_L' = R_s \| R_1 \| R_2 = 1 \| 50k\Omega \| 2k\Omega = 696\Omega$$

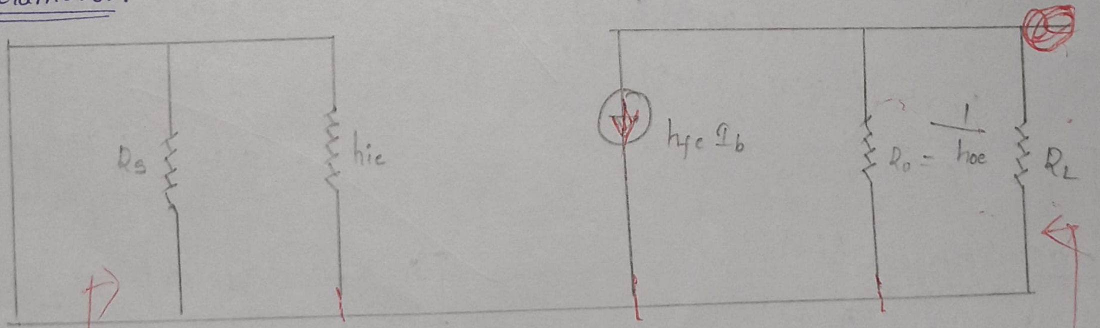
step 8: To find output impedence

$$R_o' = \frac{V_{out}}{I_{out}} = \frac{1}{h_{oe} + \frac{h_{fe} h_{re}}{R_{eq} + h_{ie}}} = 55.4k\Omega$$

$$R_o = R_c \| R_o' = 1k\Omega \| 55k\Omega = 0.982k\Omega$$

2) For CE amplifier using an PNP transistor with $h_{ie} = 1200$ ohms, $h_{re} = 0$, $h_{fe} = 36$, $h_{oe} = 2 \times 10^{-6}$ mho $R_L = 2.5k\Omega$ & Source Resistence $R_s = 500\Omega$ Construct the Complete h-parameter small signal model of the Circuit? A_v, A_i, R_i, R_o?

sol: h-parameter:



Given data;

$h_{ie} = 1200\Omega$

$h_{re} = 0$

$h_{fe} = 36$

$h_{oe} = 2 \times 10^{-6}$

$r_o = \frac{1}{h_{oe}} = 500,000$

$R_L = 2500$

$R_s = 500\Omega$

step1: To find Voltage gain A_v

$$A_v = \frac{-h_{fe} \cdot R_L'}{h_{ie} + R_s} \quad \because R_L' = R_L || R_o = 2488\,\Omega$$

$$A_v = \frac{-36 \cdot 2488}{1200 + 500} = \frac{-89568}{1700}$$

$$\boxed{A_v = -52.69}$$

step2: To find Current gain A_i !

$$A_i = \frac{i_o}{i_s} = \frac{h_{fe} \cdot R_L'}{R_L' + r_o} \boxed{= h_{fe} = 36} \quad A_i = 36 \quad (R_L' << r_o)$$

step3: To find input resistence R_i !

$$\boxed{R_i = h_{ie} = 1200\,\Omega}$$

step4: output Resistence R_o

$$R_o = r_o || R_L = \frac{500000 \cdot 2500}{500000 + 2500} \simeq 2488$$

$$\boxed{R_o = 2488}\,\Omega$$

3) Design CE amplifier for given Supply Voltage 10V, $I_c = 1.8mA$, $I_{cmin} = 1.75mA$ $I_{cmax} = 2.25$, h_{fe} min $= 180$, h_{fe} max $= 460$ Assume the lower Cutt off frequency to be 200Hz ?

Sol: Given data :→

$V_{cc} = 10\,V$

$I_c = 1.8mA$

$I_{cmin} = 1.75mA$ $I_{cmax} = 2.25mA$

h_{fe} or $\beta_{max} = 460$ h_{fe} or $\beta = 180$

low Cuttoff frequency $(f_L) = 200Hz$

Choosing CE amplifier Configuration

1, R_1, R_2 : Voltage divider bias
2, R_C - collector resistor
3, R_E - Emitter resistor
4, C_E - Capacitor across

C_{C1}, C_{C2} - Coupling Capacitor
R_L - load Resistence.

step 1 : To find V_{CE} :

$$V_{CE} = \frac{V_{CC}}{2} = \frac{10}{2} = 5V$$

$$\boxed{V_{CE} = 5V}$$

Source Voltage across R_C is :

$$V_{RC} = V_{CC} - V_{CE} = 10 - 5 = 5$$

$$\boxed{V_{RC} = 5V}$$

step 2 : find R_C

$$R_C = \frac{V_{RC}}{I_C} = \frac{5}{1.8 \times 10^{-3}} = 2.7k\Omega$$

$$\boxed{R_C = 2.7k\Omega}$$

step 3 : choose R_E for stability

$$V_{RE} \doteq 1V$$

$$R_E = \frac{V_{RE}}{I_C} = \frac{1}{1.8 \times 10^{-3}} = 560\Omega$$

3, (Voltage Divider) :

$$V_B = V_E + V_{BE} = 1V + 0.7 = 1.7V$$

$$I_B = \frac{I_C}{\beta} = \frac{1.8 \times 10^{-3}}{180} = 10\mu A$$

$$I_{R2} = 10 \times I_B = 100\mu A$$

$$\boxed{I_{R2} = 100\mu A}$$

$$R_2 = \frac{V_B}{I_{R2}} = \frac{1.7V}{100\mu A} = 17k\Omega$$

$$R_2 = 18k\Omega \rightarrow (1)$$

$$R_1 = \frac{V_{CC} - V_B}{I_{R1}} = \frac{10 - 1.7}{100\mu A} = 83k\Omega$$

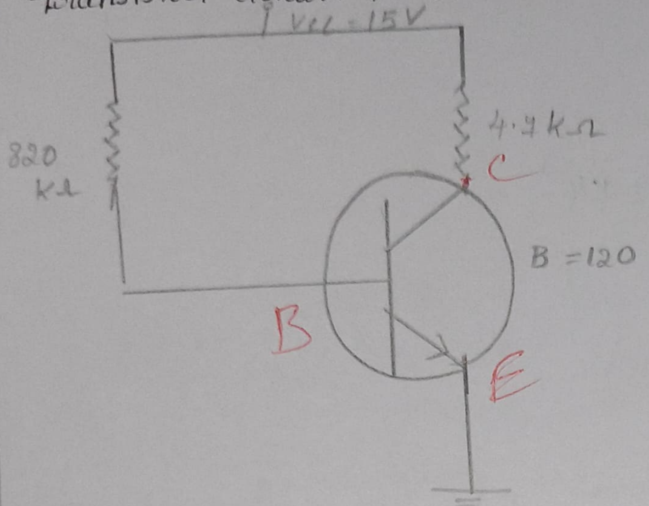
$$C = \frac{1}{2\pi f X_C} = \frac{1}{2\pi(200)(1000)}$$

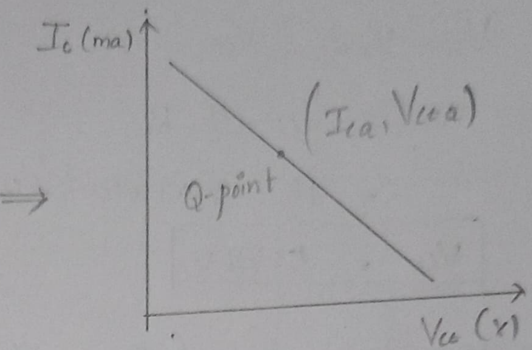
$$\boxed{C = 0.8\mu F}$$

Where $C_{C1} = C_{C2} = 1\mu F$

$$A_v = \frac{-R_C}{r_e} \qquad r_e \simeq \frac{25mV}{I_C} = \frac{25}{1.8} \simeq 13.9\Omega$$

4) Sketch dc load line and locate the operating point for fixed biasing transistor Circuit ? $V_{BE} = 0.7$





sol: **Given Data :**

$V_{cc} = 15\,V \quad R_B = 820 \times 10^3\,\Omega$

$R_c = 4.7 \times 10^3\,\Omega \quad \beta = 120$

To find Quicesent operating point (I_{CQ}, V_{CEQ})

step 1 : To find I_B

1) apply kvl @ input loop

$$V_{cc} - I_B R_B - V_{BE} = 0$$

$$I_B R_B = V_{cc} - V_{BE}$$

$$I_B = \frac{V_{cc} - V_{BE}}{R_B} = \frac{15 - 0.7}{820 \times 10^3}$$

$$\boxed{I_B = 1.74\,\mu A}$$

step 2 : To find Collector Current I_c

$$I_c = \beta I_B$$

$$= 120 \times 1.74 \times 10^{-6}$$

$$\boxed{I_c = 2.09\,mA}$$

steps : To find Voltage at Emitter - Collector

$$V_{CC} - I_C R_C - V_{CE} = 0$$

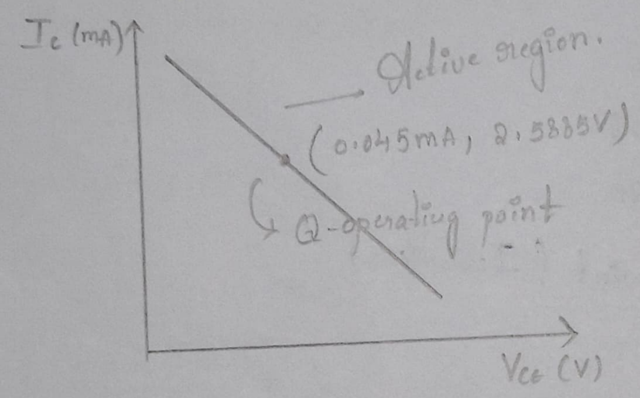
$$V_{CE} = V_{CC} - I_C R_C$$

$$= 15 - 2.09 \times 10^{-3} \times 4.7 \times 10^{3}$$

$$\boxed{V_{CE} = 5.17V}$$

Quiescent operating point $\left(\frac{I_{CQ}}{2}, \frac{V_{CEQ}}{2}\right)$

sketching the Dc load line :

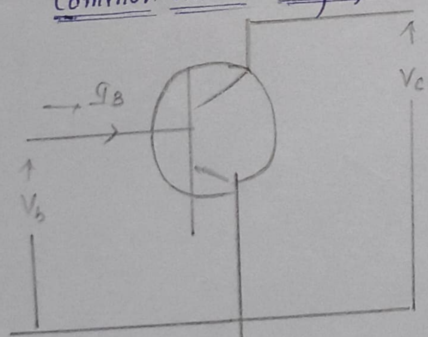


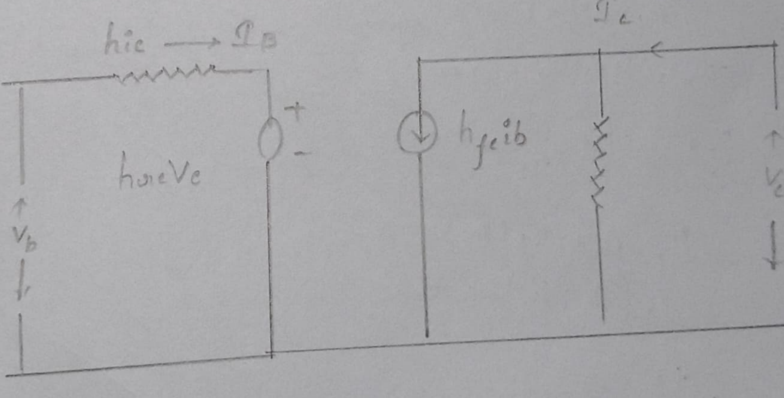
Compare the Caracteristic CE, CB, CC transistor con with respect to input resistence output resistence, Current gain!

parameter	Common Emitter	Common Base	Common collector.
Input resistence	Medium (1kΩ)	Very low (tens of Ω)	High (tens of kΩ)
output resistence	Medium to high (10kΩ - 50kΩ)	Very high (100kΩ or more)	Very low (tens to hundred)
Current gain	$\beta = h_{fe}$ typically (20 - 500)	Less than 1 (0.95 - 0.99)	Very high ($\beta+1$)
Voltage gain	High ($\simeq 100$)	High ($\simeq 50 - 500$)	no amplification.

b) Draw the h-parameter model of CE amplifier model of with Voltage divider bias and Explain the parameter!

Common emitter amplifier :





1) Current gain A_i

$$A_i = \frac{I_2}{I_1} = \frac{-I_2}{I_1}$$

$$I_2 = h_f I_1 + h_o V_2, \quad V_2 = I_L Z_L = -I_2 Z_L$$

$$I_2 = h_f I_1 - I_2 Z_L h_o$$

$$I_2 + I_2 Z_L h_o = h_f I_1$$

$$I_2 (1 + Z_L h_o) = h_f I_1$$

$$\boxed{A_I = \frac{-h_{fe}}{1 + Z_L h_{oe}}}$$

2) Input impedence (Z)

$$Z_i = \frac{V_i}{I_i} \rightarrow (1)$$

$$V_i = h_i I_1 + h_{re} V_2$$

$$Z_i = \frac{h_i I_1 + h_r V_2}{I_1} = h_i + h_r \frac{V_2}{I_1}$$

$$V_2 = -I_2 Z_L = A_I I_1 Z_L$$

$$Z_i = h_i + \frac{h_r A_I I_1 Z_L}{I_1}$$

$$Z_i = h_i + h_r A_I Z_L$$

$$Z_i = h_i - \frac{h_r Z_L h_f}{1 + h_o Z_L}$$

$$\boxed{Z_i = h_i - \frac{h_f h_r}{Y_L + h_o}}$$

3) Voltage gain (A_V)

$$A_V = V_2 / V_1$$

$$V_2 = -I_2 Z_L = A_I I_1 Z_L$$

$$A_V = \frac{A_I I_1 Z_L}{V_1} = \frac{A_I Z_L}{V_1 / I_1}$$

$$\boxed{A_V = \frac{A_I Z_L}{Z_i}}$$

5) Voltage gain

$$A_V = \frac{A_I R_L}{Z_i}$$

4) Output admittance:

$$Y_o = I_2 / V_2$$

$$I_2 = h_{fe} I_1 + h_o V_2$$

$$\frac{I_2}{V_2} = h_f \frac{I_1}{I_2} + h_o$$

$$R_s I_1 + h_i I_1 + h_r V_2 = 0$$

$$I_1 (R_s + h_i) + h_r V_2 = 0$$

$$\frac{I_1}{V_2} = \frac{-h_r}{R_s + h_i}$$

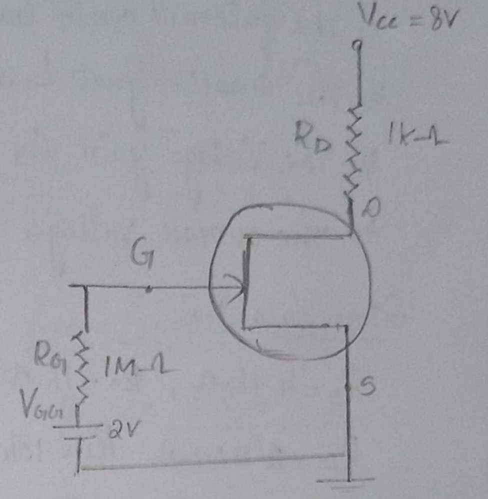
$$\boxed{Y_o = h_o - \frac{h_f h_r}{R_s + h_i}}$$

Harsha Vardhan
2400040454

Home Assignment - 2 (24EC2104)

1) For the FET biasing Circuit show in figure, utilize the necessary equation using the device's characteristic relation and perform a Complete DC bias analysis to determine ?

1) V_{DSQ} 2) I_{DQ} 3) V_{DSQ} 4) V_D



Sol:

Given Data from the Circuit

$R_G = 1M\Omega$ $\quad V_{GG} = 2V$

$R_D = 1k\Omega$ $\quad V_{cc} = 8V$

1) Apply kvl at Input loop:

$$-V_{GS} - V_{GG} - I_G R_G = 0 \qquad \therefore (I_G = 0)$$

$$-V_{GS} - V_{GG} = 0$$

$$-V_{GS} = V_{GG}$$

$$\boxed{V_{GS} = -V_{GG} = -2V}$$

2) To find I_D:

Apply shokley's equation

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

$$= 10\times10^{-3}\left(1 - \frac{(-2)}{(-4)}\right)^2$$

$$= 10\times10^{-3}\left(1 - \frac{1}{2}\right)^2$$

$$= 10\times10^{-3}\left(\frac{1}{2}\right)^2$$

$$= 10\times10^{-3}\left(\frac{1}{4}\right)$$

$$\boxed{I_D = 2.5mA}$$

3) $V_{DS} = V_{CC} - I_D R_D$

$$= 8 - 2.5(1\times10^{3})$$

$$= 8 - 2.5$$

$$\boxed{V_{DS} = 5.5V}$$

4) $V_{DS} = V_D - V_S$

$$V_D = V_{DS} + V_S \qquad (V_S = 0)$$

$$V_D = V_{DS} = 5.5V$$

$$\boxed{V_D = 5.5V}$$

2) A common Source MOSFET amplifier has $R_D = 4.7k\Omega$, $R_S = 1k\Omega$ (by passed) $R_G = 2.2M\Omega$, $R_L = 10k\Omega$, $V_{DD} = 15V$, $k_n = 2.5mA/V^2$ $V_{th} = 2V$. if the signal amplitude is 25 mV, peak calculate.

1) The quiescent drain Current I_D, drain to source V_{DS}
2) The small-signal transconductance g_m
3) The Voltage gain A_v ignoring R_L
4) the overall voltage Considering R_L

Sol: Given data :→

$R_D = 4.7k\Omega$, $R_S = 1k\Omega$ (bypass for AC)

$R_G = 2.2M\Omega$ $R_L = 10k\Omega$ $V_{DD} = 15V$ $k_n = 2.5 \times 10^{-3} A/\mu$

$V_{th} = 2V$ $V_{in} = 25m$ $V_{peak} = 0.025V$

1) The quiescent I_D, V_{DS} :→

since Gate Current is negligible ($I_G = 0$)

$V_G = 0 \rightarrow (1)$

calculate V_S :→

$V_S = I_D R_S$ or $I_S R_S$

calculate V_{GS} :→

$V_{GS} = V_G - V_S$

$= 0 - I_D R_S$

$V_{GS} = -I_D R_S \rightarrow (1)$

Drain Current

$I_D = k_n(V_{GS} - V_{th})^2$

$I_D = k_n(-I_D R_S - V_{th})^2$

$I_D = k_n(V_{GS} - V_{th})^2$

$I_D = k_n(-I_D R_S - V_{th})^2$

$= k_n(-(I_D R_S) - V_{th})^2$

$= k_n(V_{th} + I_D R_S)^2$

$I_D = 2.5y^2 - y + 2 = 0$

Where $V_G = 0$

assume $V_G = 5V$:→

$V_{GS} = V_G - I_D R_S = 5 - 1000 I_D$

$I_D = k_n (V_{GS} - V_{th})^2$

$= 2.5 \times 10^{-3} (5 - 1000 I_D - 2)^2$

$= 2.5 \times 10^{-3} (3 - 1000 I_D)^2$

let $x = I_D \longrightarrow (1)$

$x = 2.5 \times 10^{-3} (3 - 1000x)^2$

set $y = 3 - 1000x$

$x = 0.025 y^2$

$y = 3 - 1000x = 3 - 1000 (0.025y^2)$

$= 3 - 2.5y^2$

$y + 2.5y^2 = 3$

$2.5y^2 + y - 3 = 0$

solve quadratic equation

$y_1 = 0.914$

$y_2 = -1.314$

Find I_D :

$I_D = 0.025 y^2$

$= 0.025 (0.914)^2$

$\boxed{I_D = 2.09 mA}$

Calculate V_{DS} :→

$V_{DS} = V_{DD} - I_D (R_D + R_S)$

$= 15 - 2.09 \times 10^{-3} (4700 + 1000)$

$= 15 - 2.09 \times 10^{-3} (5700)$

$= 15 - 11.913$

$\boxed{V_{DS} = 3.087 V}$

Trans Conductance:

$g_m = \dfrac{2 I_D}{V_{GS} - V_{th}}$

$= \dfrac{2(2.09 mA)}{2.91 - 2}$

$\boxed{g_m = 4.6 mS}$

Voltage gain A_v ignoring R_L

$A_v = -g_m R_D$

$= -4.6 \times 4700 \times 10^{-3}$

$= -21.62$

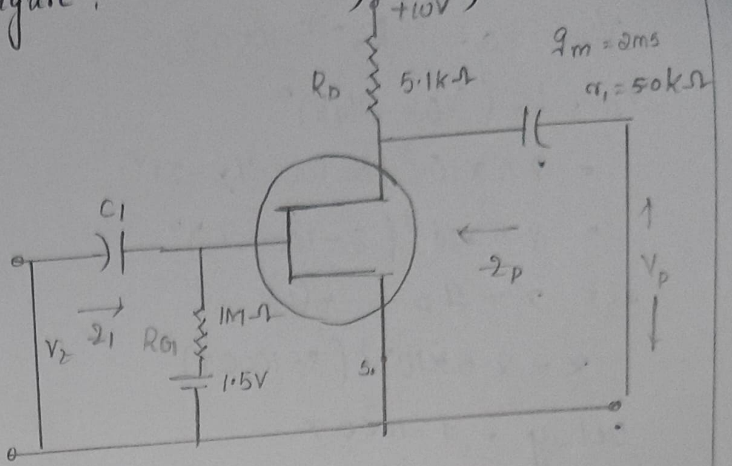
overall Voltage gain

$A_v = -g_m R_{load}$

$= -0.0046 \times 3197$

$\boxed{= -14.7}$

3) For the given Circuit shown in the figure, Estimate the input impedence, output impedence and Voltage gain?



Sol: Given Data :→

$R_D = 5.1k\Omega$, $g_m = 2mS = 0.0025$

$r_o = 50k\Omega$ $R_G = 1M\Omega$

1) Input impedance (Z_{in}) :→

JFET gate Voltage Source $V_G = 0$

where $\boxed{Z_{in} = R_G = 1M\Omega}$

2) out impedence (Z_{out}) :→

$Z_{out} \simeq (R_D \| r_o)$

$$= \frac{R_D r_o}{R_D + r_o} = \frac{5100 \times 50000}{5100 + 50,000} = \frac{255,000,000}{55,100}$$

$\boxed{Z_{out} = 4627 = 4.63k\Omega}$

3) Voltage gain!

$A_v = \frac{V_o}{V_i}$ where $A_v = -g_m (R_D \| r_o)$

$A_v = -g_m(4627) = -0.002 \times 4627 = -9.25$

$\boxed{A_v = -9.25V}$

4) For mosfet amplifier with $V_{DD} = 15V$, $R_D = 3.3k\Omega$, $R_S = 1k\Omega$ (by passed), $R_G = 2M\Omega$, $R_L = 5k\Omega$, $k_n = 2mA/V^2$ and $V_{th} = 1.5V$ Estimate the quesent operating point and Evaluate the overall Voltage

Sol:

Given Data :→

$V_{DD} = 15V$, $R_D = 3.3k\Omega$, $R_S = 1k\Omega$ (bypassed)

$R_G = 1M\Omega$ $R_2 = 5k\Omega$ $k_n = 2\times10^{-3} A/V^2$ $V_{th} = 1.5V$

To find Quiscent operating point (I_{DQ}, V_{DSQ}) :→

where $I_D = k_n (V_{GS} - V_{th})^2 \rightarrow ①$

$V_{gs} = V_g - V_s \Rightarrow V_{gs} = -V_s \quad \therefore (V_s = I_S R_S)$

$V_{gs} = -I_S R_S = -I_D R_S \quad \therefore (I_D = I_S)$

$V_{gs} = -I_D R_S \rightarrow$ sub in eq - ①

$I_D = k_n(-I_D R_S - V_{th})^2 \quad (R_S = 1\times10^3) \; (V_{th} = 1.5)$

$I_D = k_n(-I_D 10^3 - V_{th})^2 = k_n(-I_D 10^3 - 1.5)^2$

let us assume $I_D = x$ or y

$I_D = 0.002(10^3 x + 1.5)^2 = 0.002(10^6 x^2 + 3000x + 2.25)$

$x = 2000x^2 + 6x + 0.0045$

$I_D = 2000 I_D^2 + 6 I_D + 0.0045 \Rightarrow 2000 I_D^2 + 5 I_D + 0.0045 = 0$

Discriminant $b^2 - 4ac = -11 < 0$

$\therefore V_{GS} = 0 \quad I_D = k_n(-V_{th})^2$

$I_D = (-10^3 I_D + 1.5)^2 = \dfrac{7 \pm \sqrt{49-36}}{4000} = \dfrac{7 \pm \sqrt{13}}{4000}$

$\boxed{I_D = 0.842 mA}$, $\boxed{I_{D2} = 2.65mA}$

$V_D = V_{DD} - I_D R_D = 15 - (0.00265)(3300) = 6.25$

$V_{DS} = V_D - V_S = 6.25 - 2.65 \boxed{= 3.6V}$

$V_S = I_D R_S = 2.65\times10^{-3} \times 1000 \boxed{= 2.65V}$

overall Voltage gain :→

$$A_v = -g_m (R_D || r_2) \rightarrow ②$$

$$R_D || r_2 = \frac{R_D R_2}{R_D + r_2} = \frac{3300 \times 5000}{3300+5000} = \frac{16.5 \times 10^6}{8300}$$

$$A_v = -g_m (1988) \rightarrow ③$$

To find g_m transconductance

$$g_m = 2k_n (V_{gs} - V_t) \quad V_{gs} = -2.65 \quad V_{th} = -1.5$$

$$= 2(0.02)(-2.65-(-1.5)$$

$$= 2(0.02)(-1.5) \quad \text{than magnitude}$$

$$= 2(0.02)(1.5)$$

$$= 4.6 \rightarrow \text{keep in } ③$$

$$A_v = -4.6m(1988) = -9.15$$

$$\boxed{A_v = -9.15}$$

5) A sey biased n-channel JFET has $V_{DD} = 18V$, $R_D = 2.2k\Omega$, $R_S = 1.5k\Omega$, $I_{DSS} = 10mA$ and $V_p = -4V$ using relavent equation determine I_D, V_{GS}, V_{DS}?

sol: Given data :

$V_{DD} = 12V$ $R_D = 2.2 \times 10^3$, $R_S = 1.5 \times 10^3$, $I_{DSS} = 10 \times 10^{-3}$ $V_p = -4V$

To find I_D :

Apply shockley's equation $I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_p}\right)^2 \rightarrow ②$

Where $V_{gs} = V_g - V_s \quad \therefore (V_g = 0)$ grounded

$$V_{gs} = -V_s = -I_s R_s = -I_D R_s \quad \therefore (I_D = I_s) \rightarrow \text{keep in } ②$$

$$I_D = I_{DSS}\left(1 - \frac{(-I_D R_s)}{(-4)}\right)^2 = I_{DSS}\left(1 - \frac{I_D R_s}{4}\right)^2$$

$$= I_{DSS}\left(1 - \frac{I_D (1.5 \times 10^3)}{4}\right)^2$$

$$I_D = I_{DSS}\left(1 - 375\, I_D\right)^2$$

$$= 0.01\left(1 - 750\, I_D + 140625\, I_D^2\right)$$

$$\Rightarrow 1406.25\, I_D^2 - 8.5\, I_D + 0.01 = 0$$

Solving Quadratic equation.

$\boxed{I_{D1} = 4.4 \times 10^{-3}}$ $\boxed{I_{D2} = 1.6 \times 10^{-3}}$

where $V_S = I_D R_S = 1.6 \times 10^{-3} \times 1.5 \times 10^{3} = 2.400V$

$V_{GS} = -V_S = -2.400V$

$V_D = V_{DD} - I_D R_S = 18 - (1.6 \times 10^{-3})(2200) = 14.48$

$V_{DS} = V_D - V_S$

$= 14.48 - 2.40 = 12.08V$

$\boxed{V_{DS} = 12.08V}$