UNIT-I

1. Identify the parameters Required to calculate the current in a silicon PN Junction diode for a Forward - Bias voltage of 0.6V at 25°C, Given a Reverse saturation current of 10μA?

Sol:- Given data,

Voltage (V) = 0.6V

Temperature (T) = 25°C = 25 + 273 = 298 K

Reverse saturation current (I_0) = 10×10^{-6} A

for silicon diode, $\eta = 2$

known data,

$K = 1.38 \times 10^{-23}$ J/K

$Q = 1.6 \times 10^{-19}$ C

$$V_T = \frac{KT}{Q} = \frac{1.38 \times 10^{-23} \times 298}{1.6 \times 10^{-19}} = 25.7\,mV$$

formulas :-

$$I = I_0 \left[e^{\frac{V}{\eta V_T}} - 1 \right]$$

calculation,

$$I = 10 \times 10^{-6} \left[e^{\frac{0.6}{2 \times 25.7 \times 10^{-3}}} - 1 \right]$$

$$I = 10 \times 10^{-6} \left[e^{11.67} - 1 \right]$$

$\therefore$ I = 1.17 mA

2. Identify the factors involved in calculating the DC and AC Resistance of a Germanium junction diode at 25°C with $I_0 = 30\mu A$ and an applied voltage of 0.2V?

sol:- Given data,
$T = 25°C = 25 + 273 = 298\,K$

$I_0 = 30 \times 10^{-6}\,A$

$V_D = 0.2V$

$\eta = 1$ (For Germanium)

formula :-

DC Resistance $(R_{dc}) = \frac{V}{I}$

AC Resistance $(R_{AC}) = \frac{\eta V_T}{I}$

$$I = I_0 \left[e^{\frac{V_D}{\eta V_T}} - 1 \right]$$

$$V_T = \frac{KT}{Q}$$

$K = 1.38 \times 10^{-3}\,J/K$

$Q = 1.6 \times 10^{-19}\,C$

$$V_T = \frac{1.38 \times 10^{-3} \times 298}{1.6 \times 10^{-19}} = 25.7\,mV$$

$$I = 30 \times 10^{-6} \left[e^{\frac{0.2}{1 \times 0.0257}} - 1 \right] = 30 \times 10^{-6} \left[e^{7.8125} - 1 \right]$$

$= 0.0741$

$\therefore I = 74\,mA$

$$\therefore R_{dc} = \frac{0.2}{0.074} = 2.6\,\Omega$$

$$\therefore R_{AC} = \frac{1 \times 0.0257}{0.074} = 0.33\,\Omega$$

3. Identify the parameters needed to determine the Diffusion capacitance due to holes in a Ge diode with a forward-biased current of 26mA and hole mean life time of 20μsec (τ) at room temperature?

Sol:- Given data,

$T = 27°C = 27 + 273 = 300K$

$\tau = 20 \times 10^{-6}$ sec

$I = 26 \times 10^{-3}$ A

$\eta = 1$

Formulas:- $V_T = \frac{KT}{Q}$

Diffusion Capacitance $(C_D) = \frac{\tau I}{\eta V_T}$

$\therefore V_T = \frac{1.38 \times 10^{-23} \times 300}{1.6 \times 10^{-19}} = 0.026$ (or) 26 mV

$\therefore C_D = \frac{20 \times 10^{-6} \times 26 \times 10^{-3}}{1 \times 26 \times 10^{-3}}$

$= 20 \times 10^{-6}$ F (or) 20μF

4. Identify the factors needed to calculate the capacitance for a capacitor filter in a full-wave rectifier operating at 400Hz, Given a ripple factor of 10% and a 500Ω load.

Sol:- Given data,

frequency = 400Hz

Resistance $(R_L) = 500\Omega$

Ripple factor is 10% that is 0.01

Formula:- Ripple factor $= \frac{1}{4\sqrt{3} f C R_L}$

$0.01 = \frac{1}{4\sqrt{3} \times 400 \times C \times 500}$

$$0.01 = \frac{0.722 \times 10^{-6}}{C}$$

$$\therefore \text{Capacitance } (C) = \frac{0.722 \times 10^{-6}}{0.01} = 72.2 \times 10^{-6}\ F$$

$$= 72.2\ \mu F$$

5. Identify the steps to determine i) peak, average, and RMS values of current, ii) DC power output. iii) AC input power, and iv) Efficiency for a half-wave Rectifier with a 1000 Ω Resistance load, Rectifying an AC voltage with a 325 V peak value and a diode forward Resistance of 100 Ω?

Sol:- Given data,

$V_m = 325\ V$

$R_L = 1000\ \Omega$

$R_D = 100\ \Omega$

Formulas:- peak value of current $(I_m) = \frac{V_m}{R_L + R_D} = \frac{325}{1000+100} = 295.5\ mA$

$$\text{Average} = I_{avg} = \frac{I_m}{\pi} = \frac{295.5 \times 10^{-3}}{\pi} = 94.04\ mA$$

$$I_{Rms} = \frac{I_m}{2} = \frac{295.5 \times 10^{-3}}{2} = 147.7\ mA$$

DC power, $P_{dc} = I_{avg}^2 \times R_L = (94.04 \times 10^{-3})^2 \times 1000 = 8.645\ W$

AC power, $P_{AC} = I_{Rms}^2 \times (R_L + R_D) = (147.7 \times 10^{-3})^2 \times (1000+100)$

$$= (0.147)^2 \times (1100)$$

$$= 24\ W$$

Efficiency of Half-wave Rectifier $(\eta) = \frac{P_{dc}}{P_{ac}}$

$$= \frac{8.645}{24}$$

$$= 36.8\ \%$$

6. outline the approach to determine a) DC voltage across the Load, b) DC current through the load, c) DC power delivered to the load, d) PIV e) Ripple voltage and frequency, f) Rectification Efficiency for a full-wave Rectifier with a 5:1 step down center-tap transformer and a 900 Ω load. Assume a 230 V, 60 Hz AC input, with a load total Resistance of 100 Ω from the diodes and secondary coil.

Sol:- Given data,

Input voltage = 230 V AC

frequency = 60 Hz

Resistance $(R_D) = 100\,\Omega$

Load $R_L = 900\,\Omega$

Formulas:- a) Dc voltage, $(V_{out}) = \frac{230}{5} = 46\text{ V}$,

b) $V_{rms} = \frac{V_{out}}{2} = \frac{46}{2} = 23\text{ V}$

$V_{rms} = \frac{V_m}{\sqrt{2}}$, $\therefore V_m = V_{rms}\sqrt{2} = 23 \times \sqrt{2} = 32.5\text{ V}$

a) DC voltage, $V_{DC} = \frac{2V_m}{\pi} = \frac{2 \times 32.5}{\pi} = 20.7\text{V}$

b) Dc current, $I_{DC} = \frac{V_{DC}}{R_L + R_D} = \frac{20.7}{100+900} = 20.7\text{ mA}$

c) Dc power, $P_{DC} = (I_{DC})^2 \times R_L = (20.7 \times 10^{-3})^2 \times 900 = 0.386\text{ W}$

d) $PIV = 2V_m = 2 \times 32.5 = 65\text{ V}$

e) Ripple voltage, $V_{r,}V_{rms} = \sqrt{(V_{rms})^2 - (V_{DC})^2} = \sqrt{(23)^2 - (20.7)^2}$

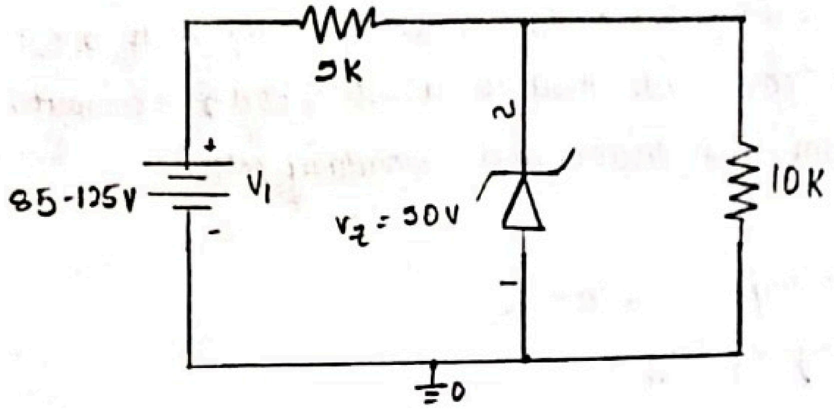
$= 10.05\text{ V}$

Frequency $= 2f = 2 \times 60 = 120\text{ Hz}$

f) Efficiency $(\eta) = \frac{P_{DC}}{P_{AC}} = \frac{(V_{DC})^2 / R_L}{(V_{rms})^2 / R_L} = \frac{(20.7)^2}{(23)^2} = 0.81$

percentage of Rectification Efficiency = 81 %.

7. Identify, conditions for Maximum and minimum current through a zener diode in a Regulator circuit, considering supply voltage and load Resistance.



Sol:- Given data,

$R_s = 5\,k\Omega$

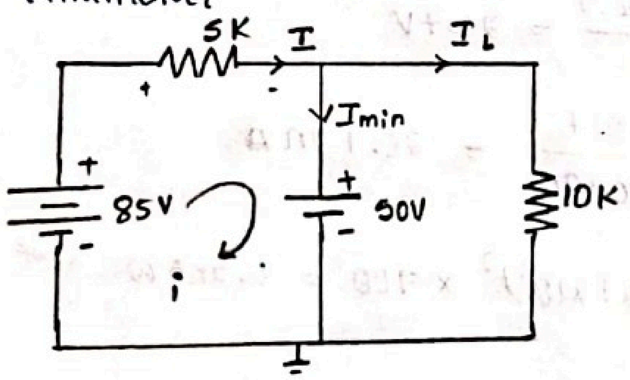
$R_L = 10\,k\Omega$

Input voltage = 85 to 125 V

Z voltage = 50 V

Re-drawing circuit:-

i) For Minimum:-



Apply KVL,

$$85 - i(5\times10^3) - 50 = 0$$

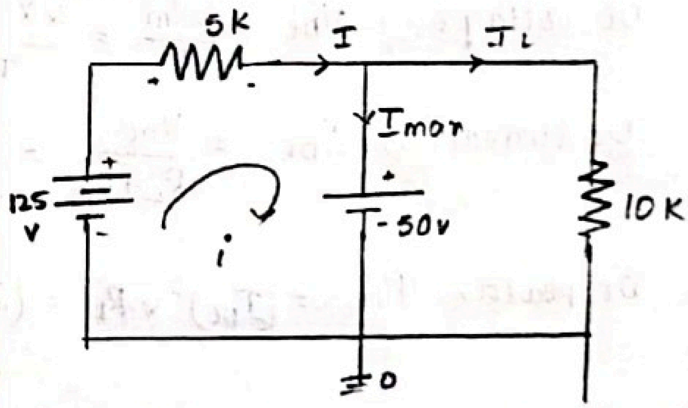
$$35 = i(5\times10^3)$$

$$i = \frac{35}{5\times10^3} = 7\,mA$$

We know that, $V = IR$

$$I_L = \frac{V}{R_L} = \frac{50}{10\times10^3} = 5\,mA$$

ii) For Maximum:-



Apply KVL,

$$125 - i(5\times10^3) - 50 = 0$$

$$75 = i(5\times10^3)$$

$$i = \frac{75}{5\times10^3} = 15\,mA$$

We know that, $V = IR_L$

$$I_L = \frac{V}{R_L} = \frac{50}{10\times10^3} = 5\,mA$$

From the circuit,

$I = I_{min} + I_L$

$\therefore I_{min} = I - I_L = 7\,mA - 5\,mA$

$\therefore I_{min} = 2\,mA.$

From the circuit

$I = I_{max} + I_L$

$I_{max} = I - I_L = 15\,mA - 5\,mA$

$\therefore I_{max} = 10\,mA$

8. Identify the steps needed to determine i) DC output voltage and ii) PIV for a half-wave Rectifier circuit with a 220V AC supply and transformer turn ratio 10:1, assuming an ideal diode.

Sol:- Given data, Input voltage = 230 V AC

Transformer turn Ratio = 10 : 1

Formula: $V_{out} = \frac{220}{10} = 22\,V$

$V_{rms} = \frac{220}{10} = 22\,V$

$\therefore V_{rms} = \frac{V_m}{\sqrt{2}} \Rightarrow V_m = \sqrt{2}\,V_{rms} = \sqrt{2} \times 22 = 31.11\,V$

i) Dc output voltage $V_{DC} = \frac{V_m}{\pi} = \frac{31.11}{\pi} = 9.902\,V$

ii) $PIV = V_m = 31.11\,V$

9. Determine the process to find the average and RMS load current in a full-wave Rectifier circuit, Given an RMS Secondary voltage of 50 V (from center tap to each end), a load Resistance of 900Ω, and a combined diode and transformer resistance of 100Ω.

Sol:- Given data, $R_D = 100\,\Omega$

$R_L = 900\,\Omega$

RMS secondary voltage = 50 V = V_{rms}

Formulas:-

$$\text{Load current } I_m = \frac{V_m}{R_D + R_L} = \frac{V_{rms} \times \sqrt{2}}{R_D + R_L} = \frac{50 \times \sqrt{2}}{900+100} = \frac{70.7}{1000} = 70.7 \text{ mA}$$

$$\text{Average load current}, I_{DC} = \frac{2 I_m}{\pi} = \frac{2 \times 70.7 \times 10^{-3}}{\pi} = 45 \text{ mA}$$

$$\text{RMS value of load current}, I_{RMS} = \frac{I_m}{\sqrt{2}} = \frac{70.7 \times 10^{-3}}{\sqrt{2}} = 50 \text{ mA}.$$

10. Identify the parameters a LED driver circuit with a 5V supply, 2V LED forward voltage, and 20mA current requirement. calculate the needed series resistor value.

Sol:- Given data,

Supply voltage = 5V

$V_{LED} = 2V$

$I = 20 \times 10^{-3}$ A

Formulas :-

$$R = \frac{V}{I} = \frac{V_{supply} - V_{LED}}{I}$$

$$\therefore V_R = V_{supply} - V_{LED} = 5V - 2V = 3V.$$

$$\text{Resistor value } (R) = \frac{3V}{20 \times 10^{-3}} = 150 \ \Omega.$$

1) Calculate the values of the I_B and current amplification factor (α) in a common base transisor circuit, the emitter current I_E is 10mA and the collector current I_C is 9.8mA.

Sol:- Given that:-

$I_E = 10mA$.

$I_C = 9.8 mA$

$\rightarrow I_E = I_B + I_C$

$10 \times 10^{-3} = I_B + 9.8 \times 10^{-3}$

$I_B = 9.8 \times 10^{-3} - 10 \times 10^{-3}$

$I_B = 0.2 mA$,

$\rightarrow \alpha = \frac{I_C}{I_E}$

$= \frac{9.8 \times 10^{-3}}{10 \times 10^{-3}}$

$= 0.98$.

2) Calculate α, I_C and I_E for Ge Transistor, $\beta = 50$, $I_{CBO} = 5\mu A$ and $I_B = 100\mu A$.

Given that:-

$\beta = 50$

$I_{CBO} = 5\mu A$

$I_B = 10\mu A$.

$\rightarrow I_C = \beta I_B + (1+\beta) I_{CBO}$

$I_C = 50 \times 100 \times 10^{-6} + (1+50) 5 \times 10^{-6}$

$I_C = 5 \times 10^{-3} + 51 \times 5 \times 10^{-6}$

$I_C = 5.255 mA$

$\rightarrow \quad I_E = I_C + I_B$

$I_E = 5.255mA + 0.1mA$

$I_E = 5.355mA.$

$\rightarrow \quad \alpha = \frac{\beta}{1+\beta}.$

$\alpha = \frac{50}{51} = 0.9804$

3) Determine the common base dc current gain and base current, in a common base connection, the emitter current is I_E is 6.28mA and the collector current I_C is 6.20 mA.

Sol:- Given that :-

$I_E = 6.28mA$

$I_C = 6.20 mA$

$\Rightarrow \alpha = \frac{I_C}{I_E} = \frac{6.20 \times 10^{-3}}{6.28 \times 10^{-3}} = 0.987.$

$\Rightarrow \quad I_E = I_B + I_C$

$I_B = I_E - I_C$

$I_B = 6.28 \times 10^{-3} - 6.20 \times 10^{-3}.$

$I_B = 0.08 mA.$

4) Calculate the values of I_C and I_E for a transistor with $\alpha_{dc} = 0.99$ and $I_{CBO} = 5\mu A$, I_B is measured as $20\mu A$.

Sol:- Given that:-

$\alpha_{dc} = 0.99$

$I_{CBO} = 5\mu A$

$I_B = 20\mu A$

$$\Rightarrow \quad I_C = \frac{\alpha_{dc} I_B}{1-\alpha_{dc}} + \frac{I_{CBO}}{1-\alpha_{dc}}$$

$$= \frac{0.99 \times 20 \times 10^{-6}}{1-0.99} + \frac{5 \times 10^{-6}}{1-0.99}$$

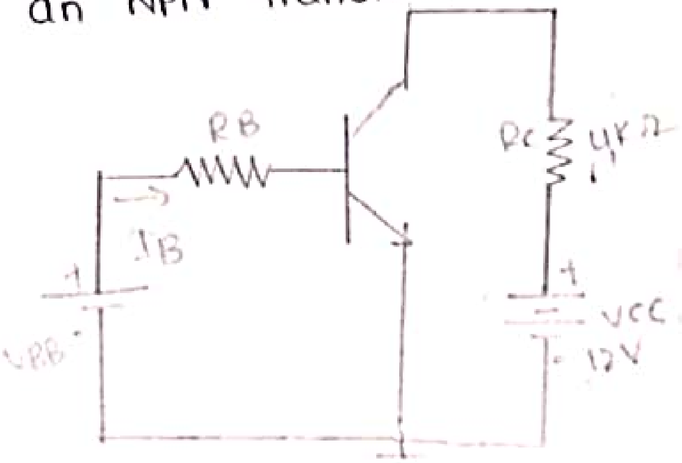
$$= 2.48 mA$$

$$\Rightarrow \quad I_E = I_B + I_C$$

$$I_E = 20 \times 10^{-6} + 2.48 \times 10^{-3}$$

$$I_E = 2.5 mA.$$

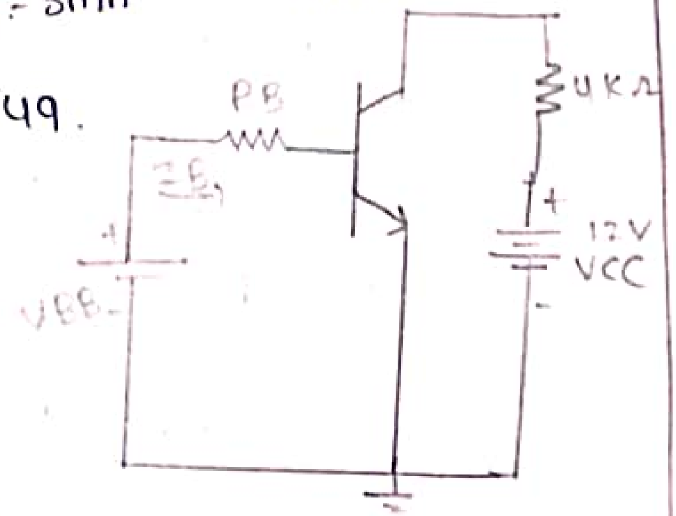
5) Determine the base current required in order for the transistor to enter into saturation region of given an npn transistor switch is 0.98.



<u>Sol:-</u> given that :- $\alpha = 0.98$, $I_{CO} = 2\mu A$; $I_{CEO} = 1.6\mu A$, $V_{CC} = 12V$ and $R_C = 4k\Omega$

$$I_{C(sat)} = \frac{V_{CC}}{R_C} = \frac{12}{4 \times 10^3} = 3mA$$

$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{1-0.98} = 49.$$



$$I_{B(min)} = \frac{I_{C(sat)}}{\beta}$$

$$= \frac{3 \times 10^{-3}}{49}$$

$$= 61.224 \times 10^{-6}$$

$$= 61.224 \mu A.$$

6) Calculate the emitter current with $\alpha_{dc} = 0.99$ and $I_{CBO} = 50\mu A$, I_B is measured as 1mA.

Sol: Given that $\alpha_{dc} = 0.99$

$I_{CBO} = 50\mu A$.

$I_B = 1mA$.

$$I_C = \frac{\alpha_{dc} I_B}{1-\alpha_{dc}} + \frac{I_{CBO}}{1-\alpha_{dc}}$$

$$= \frac{0.99(1\times10^{-3})}{1-0.99} + \frac{50\times10^{-6}}{1-0.99}$$

$$= \frac{0.99\times10^{-3}}{0.01} + \frac{50\times10^{-6}}{0.01}$$

$$= 99mA + 5mA$$

$$I_C = 104mA.$$

$$I_E = I_B + I_C$$

$$= 1mA + 104mA.$$

$$I_E = 105mA$$

7) Determine I_C, I_E and for a transistor circuit having $I_B = 15\mu A$ and $\beta = 150$

Sol: Given that:-

$I_B = 15\mu A$

$\beta = 150$

$\Rightarrow I_C = \beta I_B.$

$= 150(15\times10^{-6})$

$= 2.25mA$

$\Rightarrow I_E = I_C + I_B$

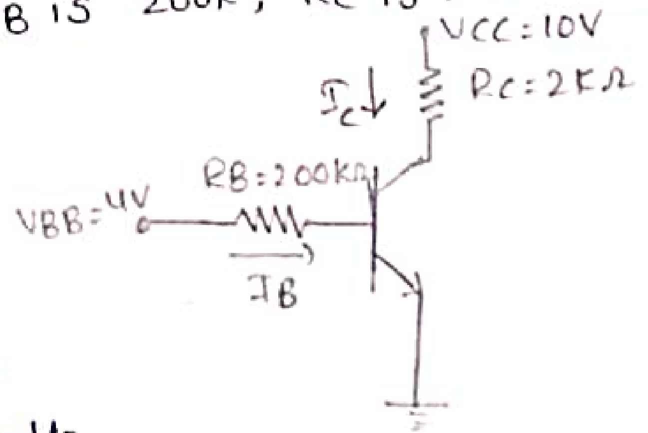
$I_E = 2.25\times10^{-3} + 15\times10^{-6}$

$I_E = 2.265mA.$

$$\Rightarrow \alpha = \frac{\beta}{1+\beta}$$

$$= \frac{150}{151} = 0.9934.$$

3) Determine the base, collector and emitter currents and VCE for the CE circuit VCC is 10V, VBB is 4V, RB is 200K, RC is 2K, VBE is 0.7V and β is 200.



Sol:-

Given that :-

$V_{CC} = 10V$

$V_{BB} = 4V$

$R_B = 200 K\Omega$

$R_C = 2 K\Omega.$

$V_{BE} = 0.7V$

$\beta = 200.$

$$\Rightarrow I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{4-0.7}{200\times10^3} = 16.5 \mu A.$$

$$\Rightarrow I_C = \beta I_B = 200(16.5\times10^{-6})$$
$$= 3.3mA$$

$$\Rightarrow I_E = I_B + I_C = 16.5\times10^{-6} + 3.3\times10^{-3}$$
$$= 3.3165mA$$

$$\Rightarrow V_{CE} = V_{CC} - I_C R_C$$
$$= 10 - 3.3\times10^{-3}\times2\times10^{3}$$
$$= 3.4V.$$

9) Calculate the value of base current, the common base dc current gain of a transistor is 0.967. if the emitter current is 10 mA.

Sol:- Given that :-

$\alpha = 0.967$

$I_E = 10 \times 10^{-3}$.

$\alpha = \frac{I_C}{I_E}$

$I_C = \alpha I_E$

$I_C = 0.967 (10 \times 10^{-3})$

$I_C = 9.67 \text{ mA}$.

$I_E = I_B + I_C$

$I_B = I_E - I_C$

$I_B = 10 \times 10^{-3} - 9.67 \times 10^{-3}$

$I_B = 0.33 \text{ mA}$.

10) Determine the i) β of the transistor ii) α of the transistor iii) current I_E of transistor has $I_B = 100 \mu A$ and $I_C = 2 mA$

Sol:- given that :-

$I_B = 100 \mu A$

$I_C = 2 mA$.

i) $\beta = \frac{I_C}{I_B}$.

$\beta = \frac{2 \times 10^{-3}}{100 \times 10^{-6}} = \frac{2 \times 10^{-3}}{1 \times 10^{-4}} = 20$

ii) $\alpha = \frac{\beta}{1+\beta}$

$= \frac{20}{21} = 0.952$

iii) $I_E = I_B + I_C$

$= 100 \times 10^{-6} + 2 \times 10^{-3}$

$= 2.1 \times 10^{-3} A$.

$= 2.1 \text{ mA}$.

1) Determine the drain current IDS, gm and gmo of an N-channel JFET has IDSS is 10 mA and Vp is -5V for VGS is -2V in the pinch-off region

Sol: Given data

$I_{DSS} = 10 mA$

$V_P = -5V$

$V_{GS} = -2V$

$$I_{DS} = I_{DSS}\left[1 - \frac{V_{GS}}{V_P}\right]^2$$

$$= 10\times10^{-3}\left[1 - \left(\frac{-2}{-5}\right)\right]^2$$

$$= 10\times10^{-3}\left[1 - \frac{2}{5}\right]^2$$

$$= 10\times10^{-3}\left[\frac{3}{5}\right]^2$$

$$= 3.6\times10^{-3}$$

$I_{DS} = 3.6\, m\,Amps$

$$g_{mo} = \frac{-2 I_{DSS}}{V_P}$$

$$= \frac{(-2)\times 10\times10^{-3}}{(-5)}$$

$$= 2\times2\times10^{-3}$$

$\therefore$ **$g_{mo} = 4\times10^{-3}$ ℧**

$$g_m = g_{mo}\left[1 - \frac{V_{GS}}{V_P}\right]$$

$$= 4\times10^{-3}\left[1 - \left(\frac{-2}{-5}\right)\right]$$

$$= 4\times10^{-3}\left[\frac{3}{5}\right]$$

$g_m = 2.4\times10^{-3}$ ℧

2) Determine the drain current I_{DS}, g_m and g_{mo} when a JFET has $V_P = -5V$, $I_{DSS} = 8\,mA$ and $V_{GS} = -2.5V$

Sol: Given data:

$I_{DSS} = 8mA$

$V_P = -5V$

$V_{GS} = -2.5V$

$$I_{DS} = I_{DSS}\left[1 - \frac{V_{GS}}{V_P}\right]^2$$

$$= 8\times10^{-3}\left[1 - \left(\frac{-2.5}{-5}\right)\right]^2$$

$$= 8\times10^{-3}\left[1 - \frac{1}{2}\right]^2$$

$$= 8\times10^{-3}\left(\frac{1}{4}\right)$$

$$= 2\times10^{-3}$$

$$\boxed{I_{DS} = 2mA}$$

$$g_{mo} = \frac{-2I_{DSS}}{V_P}$$

$$= \frac{(-2)(8\times10^{-3})}{(-5V)}$$

$$\boxed{g_{mo} = 3.2\times10^{-3}\ \mho}$$

$$g_m = g_{mo}\left[1 - \frac{V_{GS}}{V_P}\right]$$

$$= 3.2\times10^{-3}\left[1 - \left(\frac{-2.5}{-5}\right)\right]$$

$$= 3.2\times10^{-3}\left(1 - \frac{1}{2}\right)$$

$$g_m = 3.2\times10^{-3}\left(\frac{1}{2}\right)$$

$$\boxed{g_m = 1.6\times10^{-3}\ \mho}$$

3) calculate the values of V_{GS} and V_P when a FET has drian current of 4 mA. If I_{DSS} is 8 mA and $V_{GS(off)}$ is -6 V

Sol Given data $I_D = 4mA$

$I_{DSS} = 8mA$

$V_{GS(off)} = -6V$

$$\sqrt{\frac{I_D}{I_{DSS}}} = 1 - \frac{V_{GS}}{V_{GS(OFF)}}$$

$$V_{GS} = \left(1 - \sqrt{\frac{I_D}{I_{DSS}}}\right) V_{GS(OFF)}$$

$$= \left(1 - \sqrt{\frac{4 \times 10^{-3}}{8 \times 10^{-3}}}\right)(-6v)$$

$$\boxed{V_{GS} = -1.75v}$$

$V_P = V_{GS(OFF)}$

$$\boxed{V_P = -6V}$$

4) Determine the pinch-off voltage for an N-channel silicon FET with a channel width of 5.6×10^{-4} cm and a donor concentration of $10^{15}/cm^3$. Given the dielectric constant of si is 12.

Sol Given data: $V_P = \frac{qN_d \alpha^2}{2\epsilon}$ = Formula

Given data: $N_d = 10^{15}/cm^3$

$\alpha = 5.6 \times 10^{-4}$ cm

$\varepsilon_r = 12$

let $q = 1.6 \times 10^{-19}$ C

$\varepsilon = \varepsilon_r \cdot \varepsilon_0$ $\quad \because \varepsilon_0 = 8.85 \times 10^{-14}$ F/cm

$\varepsilon = 12 \times 8.85 \times 10^{-14}$

$\varepsilon = 1.062 \times 10^{-12}$ F/cm

$$V_P = \frac{(1.6\times10^{-19})(10^{15})(5.6\times10^{-4})}{(2)(1.062\times10^{-12})}$$

$$= \frac{5.0176\times10^{-11}}{2.124\times10^{-12}}$$

$$\boxed{V_P = 23.63\,V}$$

5) Determine drain current when V_{GS} is -1.5 V in N channel JFET I_{DSS} is 10mA and V_P is -33V.

Sol Given data

$V_{GS} = -1.5V$

$I_{DSS} = 10mA$

$V_P = -33$

$$I_{DS} = I_{DSS}\left[1 - \frac{V_{GS}}{V_P}\right]^2$$

$$= 10\times10^{-3}\left[1-\left(\frac{-1.5}{-33}\right)\right]^2$$

$$= 10\times10^{-3}\left[1-0.045\right]^2$$

$$= 10\times10^{-3}(0.955)^2$$

$$= 10\times10^{-3}(0.912)$$

$$= 9.12\times10^{-3}$$

$I_{DS} = 9.12mA$.

6) Determine the value of transconductance at V_{GS} is $-4V$ of the N-channel JFET has I_{DSS} is 20mA, V_P is $-8V$ and g_{mo} is 5000µS.

Sol: Given data: $V_{GS} = -4V$

$I_{DSS} = 20mA$

$V_P = -8V$

$$g_{mo} = 5000 \mu S$$

$$g_m = g_{mo}\left[1 - \frac{V_{GS}}{V_P}\right]$$

where g_{mo} = maximum transconductance

$$g_m = 5000 \times \left(1 - \left(\frac{-4}{-8}\right)\right)$$

$$= 5000 \times \left(1 - \frac{1}{2}\right)$$

$$= 5000\left(\frac{1}{2}\right)$$

$$\boxed{g_m = 2500 \mu S}$$

∴ transconductance $g_m = 2500 \mu S$

7) Determine the trans conductance of a JFET its amplification factor is 94 and drain resistance is 30kΩ

Sol Given data

$\mu = 94$

$R_D = 30k\Omega \quad = 30 \times 1000 \ \Omega$

transconductance $g_m = \frac{\mu}{R_D}$

$$= \frac{94}{30000}$$

$$\boxed{g_m = 3.13 \ k℧}$$

8) Determine the output voltage of a NMOS transistor in a circuit has a supply voltage of 5V and a drain resistance of 1kΩ, If the drain current is 2mA.

Sol: Given data

supply voltage $V_{dd} = 5V$

Drain resistance $R_D = 1k\Omega$

Drain current $(I_d) = 2mA$

By ohm law

$$V_{out} = V_{dd} - (I_d \times R_d)$$

$$= 5V - (2mA \times 1k\Omega)$$

$$V_{out} = 5V - 2V$$

$$\boxed{V_{out} = 3V}$$

9) Build an appropriate biasing circuit using with V_{DD} is 30V of JFET is to be operated at a quiescent point defined by I_D is 4mA. V_{DS} is 8V and V_{GS} is -2V.

Given data $V_{DD} = 30V$

$I_D = 4mA$

$V_{DS} = 8V$

$V_{GS} = -2V$

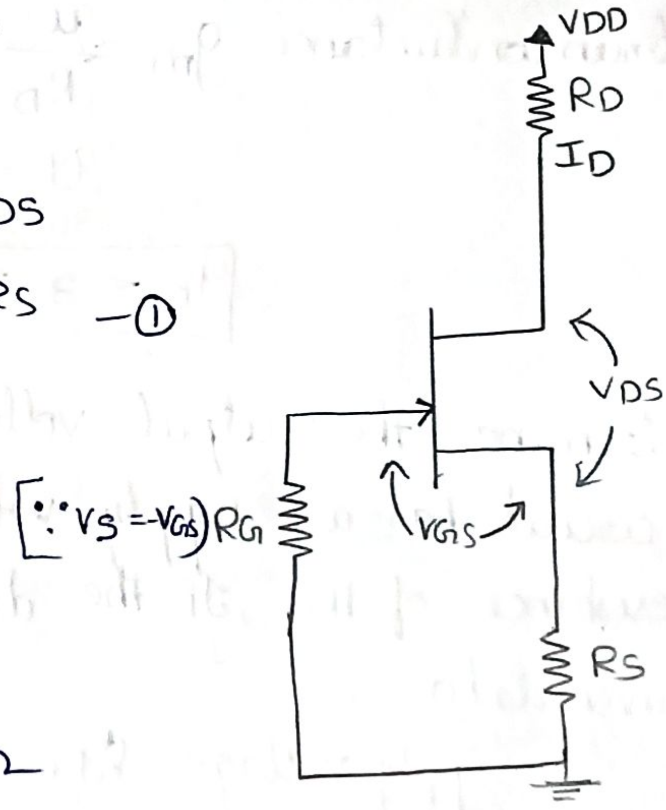
loop eqn

$$V_{DD} - I_D R_D - V_{DS} - I_D R_S = 0$$

$$V_{DD} = I_D R_D + V_{DS} + I_D R_S$$

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

$$R_D = \frac{V_{DD} - V_{DS} - I_D R_S}{I_D} \quad -①$$



But $R_S = \frac{V_S}{I_D}$

$$= \frac{-V_{GS}}{I_D}$$

$$R_S = \frac{2}{4 \times 10^{-3}} = 500\Omega$$

From eq ① $R_D = \frac{30 - 8 - (4 \times 10^{-3} \times 500)}{4 \times 10^{-3}}$

$R_D = 5000\,\Omega$

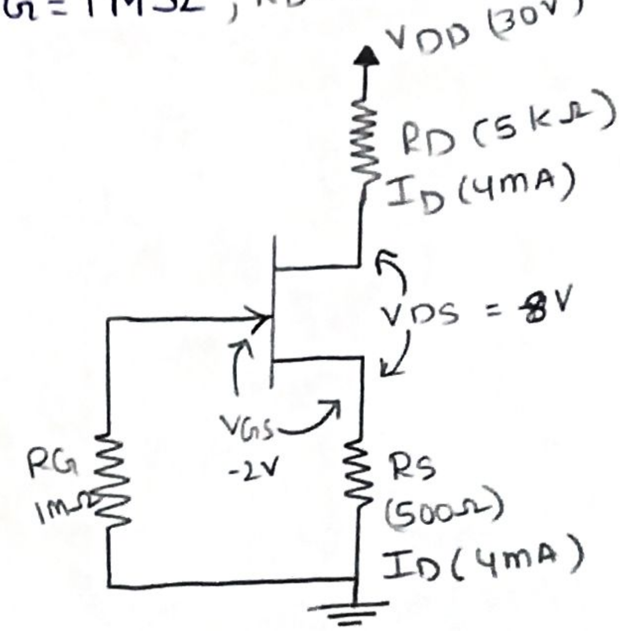
$R_D = 5k\Omega$

R_G is very large. then

$R_G = 1M\Omega$

To build an appropriate biasing circuits of JFET we need $V_{DD} = 30V$, $I_D = 4mA$, $V_{DS} = 8V$, $V_{GS} = -2V$

$R_S = 500\Omega$, $R_G = 1M\Omega$, $R_D = 5k\Omega$



10) Calculate the energy consumed per switching cycle of BI MOS gate drives a load capacitance of 20pF with a supply voltage 5V

Given data

$C_L = 20pF$,

$V_{DD} = 5V$

Energy $E = \frac{1}{2} C_L V_{DD}^2$

$$E = \frac{1}{2} \times 20 \times 10^{-12} \times (5)^2$$

$$= 10 \times 10^{-12} \times 25$$

$$E = 250 \times 10^{-12}$$

$$\boxed{E = 250\ pJ}$$

Unit-4

1 Calculate the collector current and collector to Emitter voltages values in the fixed-bias compensation method of transistor with $\beta = 100$ are used V_{CC} is 9V R_C is 3KΩ R_B is 530K and $V_{BE} = 0.7V$.

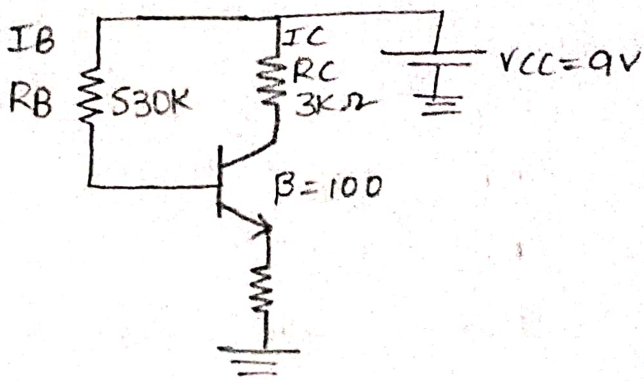
Sol: Given $\beta = 100$

$R_C = 3K\Omega$

$R_B = 530$

$V_{CC} = 9V$

$V_{BE} = 0.7V$



$V_{CC} - i_B R_B - V_{BE} = 0$

$i_B R_B = V_{CC} - V_{BE}$

$$i_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{9-0.7}{530} = \frac{8.3}{530} = 0.015$$

$= 15.66\,\mu A$

$i_{CQ} = \beta I_B$

Note: R_B is 530K

$= 100(15.66 \times 10^{-6})$

$= 1.566mA$

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

$= 9 - (1.566 \times 10^{-3})(300 \times 10^3)$

$= 9 - 469.8$

$= -460.8.$

2. Determine the h parameters for CC configuration with the help of h parameters for CE configuration are hie is 21600Ω hfe is 100, hre is 0.02 x10⁻² and hoe is 5x10⁻⁶ A/v.

Sol: Given

$h_{ie} = 2600\Omega$

$h_{fe} = 100$

$h_{re} = 0.02 \times 10^{-2} = 0.0002$

$h_{oe} = 5 \times 10^{-6}$ A/V

1. input impedence (hic)

$$h_{ic} = h_{ie} + \frac{1 + h_{fe}}{h_{oe}}$$

$$= 2600 + \frac{1+100}{5 \times 10^{-6}} = 2600 + \frac{101}{5 \times 10^{-6}}$$

$$= 20.2 M\Omega$$

2. Forward current gain (hfc)

$$h_{fc} = \frac{h_{fe}}{1+h_{fe}} = \frac{100}{1+100} = \frac{100}{101} = 0.9901$$

3. Reverse voltage gain (hrc)

$$h_{rc} = \frac{h_{re}}{1+h_{fe}} = \frac{0.0002}{101} = 1.98 \times 10^{-6}$$

4. output impedence (hoc)

$$h_{oc} = h_{oe}$$

$$= 5 \times 10^{-6} \text{ A/V}$$

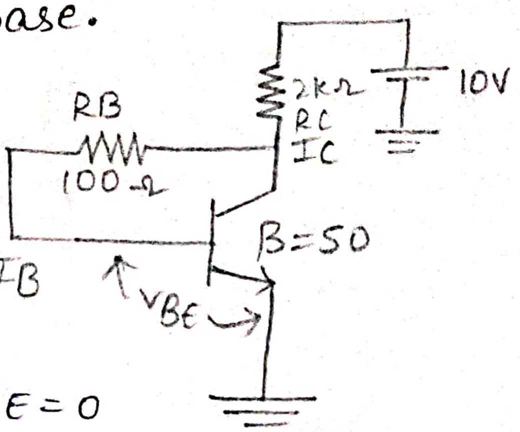
3. Determine the quiescent point in an NPN transistor, if β is 50 used in common Emitter circuit with Vcc is 10V and RC is 2kΩ The bias is obtained by connecting 100kΩ resistor from collector to base.

Sol: Given $\beta = 50$

$V_{CC} = 10V$

$R_C = 2k\Omega$

$R_B = 100k\Omega$



$V_{CC} - R_C(I_C + I_B) - R_B I_B - V_{BE} = 0$

$V_{CC} - R_C[\beta I_B + I_B] - R_B I_B - V_{BE} = 0$

$V_{CC} - R_C I_B[1+\beta] - R_B I_B - V_{BE} = 0$

$V_{CC} - V_{BE} = I_B[R_C(1+\beta) + R_B]$

$\left[I_C = \beta I_B \quad \beta = \frac{I_C}{I_B} \quad I_B = \frac{I_C}{\beta} \right]$

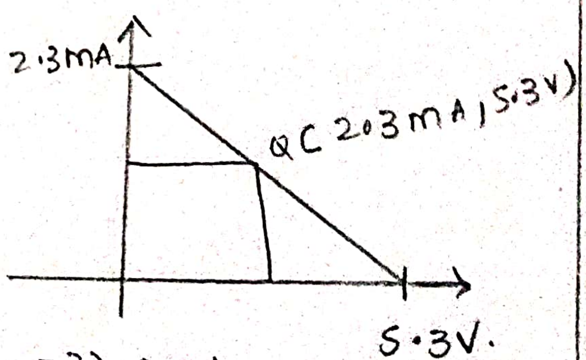
$$I_B = \frac{V_{CC} - V_{BE}}{R_C(1+\beta) + R_B} = \frac{10 - 0.7}{2\times10^3(51) + 100\times10^3}$$

$$= \frac{9.3}{202000} = 0.046\times10^{-3}.$$

$I_{CQ} = \beta I_B = 50 \times 0.046\times10^{-3} = 2.3\times10^{-3} = 2.3mA$

$V_{CC} - R_C(I_C + I_B) - V_{CE} = V_{CE} = 0$

$V_{CC} - R_C[\beta I_B + I_B] - V_{CE} = 0$



$V_{CEQ} = V_{CC} - R_C[\beta I_B + I_B]$

$= V_{CC} - R_C I_B(1+\beta)$

$= 100 - (2\times10^3)(0.046\times10^{-3})(51)$

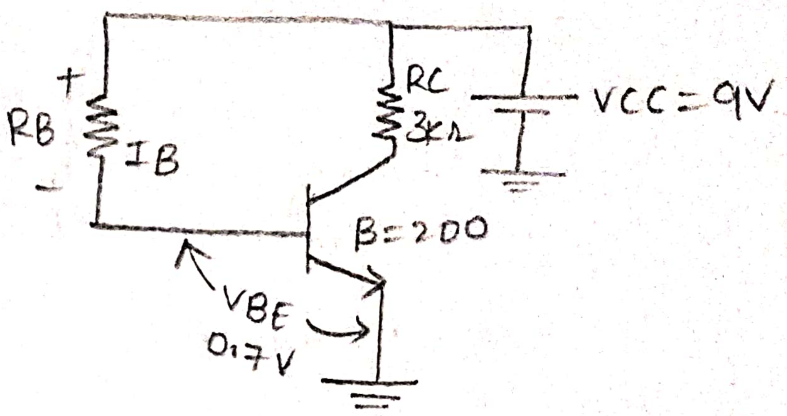
$= 100 - 4.692$

$= 5.3V$

4. Examine the operating point in a silicon transistor with a fixed bias, $V_{CC} = 9V$, $R_C = 3k\Omega$, $R_B = 1M\Omega$, $\beta = 200$, $V_{BE} = 0.7$

Sol: Given

Circuit diagram



$V_{CC} = 9V$

$R_B = 1M\Omega$

$R_C = 3k\Omega$

$V_{BE} = 0.7V$

$\beta = 200$

$V_{CC} - i_B R_B - V_{BE} = 0$

$V_{CC} - V_{BE} = i_B R_B$

$$i_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{9 - 0.7}{1 \times 10^6} = 8.3 \times 10^{-6} \text{ Amp}$$

$i_B = 8.3 \, \mu\text{Amp}$

$i_C = \beta I_B = 200 \times (8.3 \times 10^{-6}) = 1.6 \times 10^{-3}$ Amp

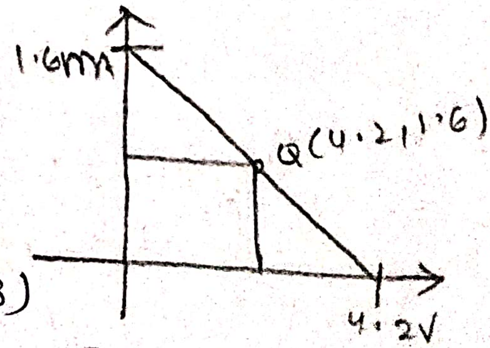
$i_{CQ} = 1.6 \times 10^{-3}$ Amps

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

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

$= 9 - (1.6 \times 10^{-3})(3 \times 10^3)$

$V_{CE} = 4.2V$

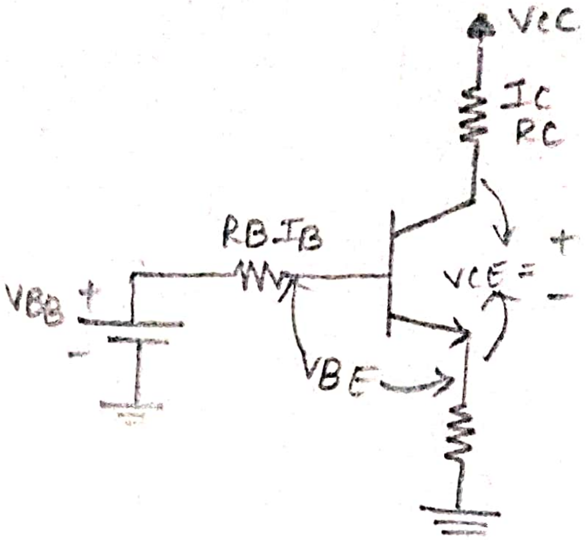


$S = 1 + \beta$

$= 1 + 200 = 201$

5. Determine the RE value of a silicon transistor with is β is 100 is to be used in self bias circuit such that Q point corresponds to VCE is 12V, Ic is 2mA, Vcc is 24V and Rc is 5kΩ

Sol: Given



$V_{CE} = 12V$

$I_C = 2mA$

$V_{CC} = 24V$

$R_C = 5k\Omega$

$\beta = 100$

$$I_B = \frac{I_C}{\beta} = 0.02mA$$

$$I_E = I_B + I_C = 0.02 + 2 = 2.02mA$$

WKT

$$V_{CEQ} = V_{CC} - I_C R_C - I_E R_E$$

$$R_E = \frac{V_{CC} - I_C R_C - V_{CEQ}}{I_E}$$

$$R_E = \frac{24 - 2\times10^{-3} \times 5\times10^{3} - 12}{2.02\times10^{-3}}$$

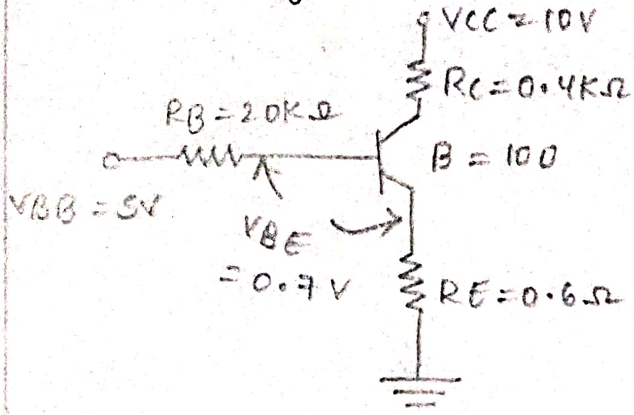
$$= \frac{24 - 10 - 12}{2.02\times10^{-3}}$$

$$= \frac{2}{2.02\times10^{-3}}$$

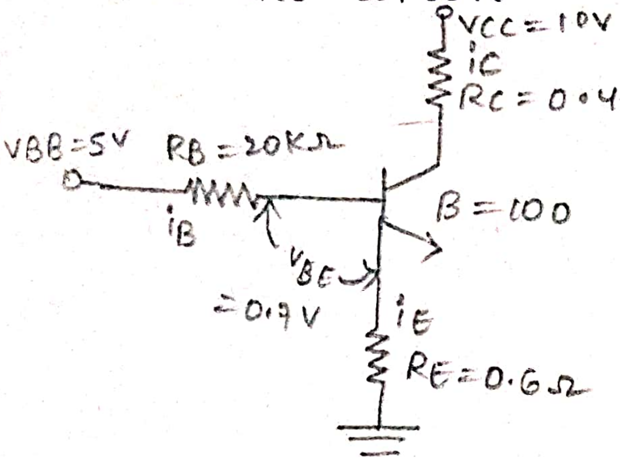
$$= 990.09\Omega$$

$$= 0.99k\Omega$$

6. Determine the Queisent values of as shown in following circuit diagram assume that $\beta = 100$ and VBE is 0.7V.



Sol: Redraw the circuit



By applying KVL

$$V_{BB} = I_B R_B + V_{BE} + I_E R_E$$

$$I_E = I_B + I_C = I_B + \beta I_B$$
$$= (1+\beta) I_B$$

$$I_B = \frac{V_{BB} - V_{BE}}{R_B + (1+\beta) R_E}$$

Given

$V_{BB} = 5V$, $R_B = 20K\Omega$, $R_C = 0.4K\Omega$

$\beta = 100$, $R_E = 0.6\Omega$, $V_{BE} = 0.7V$

$$= \frac{5 - 0.7}{20 \times 10^3 + 101(600)} = \frac{4.3}{80600}$$

$$= 53.34 \mu A$$

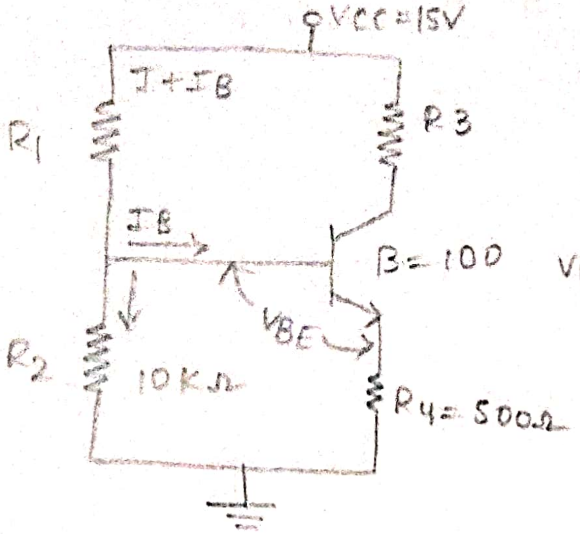
$$I_C = \beta I_B = 100(53.34 \times 10^{-6}) = 5.334 mA$$

$$I_E = I_C + I_B = 5.334 \times 10^{-3} + 53.34 \times 10^{-6} = 5.3874$$

$$V_{CE} = V_{CC} - I_C R_C - I_E R_E = 10 - 5.334 \times 10^{-3} \times 400 -$$
$$5.38734 \times 10^{-3} \times 600$$
$$= 4.634 V$$

The Q point is at $V_{CEQ} = 4.634V$ and $I_{CQ} = 5.334mA$.

7. Calculate R_1 and R_3 as shown in the following circuit, if I_C is 2mA and V_{CE} is 3V.



V

Vv

This Problems Discussed in the Notes

Sol: Given

v

$V_{CC} = 15V$

$\beta = 100$

$V_{BE(on)} = 0.6V$

$R_4 = 500\,\Omega$

$R_2 = 10k\Omega$

$I_C = 2mA$

$V_{CE} = 3V$

I_B is negiable

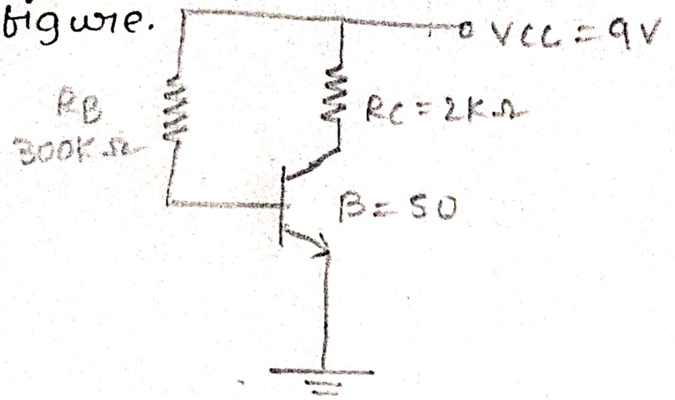
assumptio $I_B = I_C$

$$R_1 = \frac{V_{CC} - V_{BE}}{i_b}$$

$$= \frac{15 - 0.6}{2 \times 10^{-3}} = \frac{14.4}{2 \times 10^{-3}} = 7200$$

$$R_3 = \frac{V_{CE}}{I_C} = \frac{3V}{2mA} = \frac{3}{2 \times 10^{-3}} = 1500$$

8. Calculate the collector current and collector to emitter voltage for the given circuit as shown in following figure.



Sol: Given $V_{CC} = 9V$

$R_C = 2k\Omega$

$\beta = 50$

$R_B = 300k\Omega$

$I_C = \beta i_b$

$$I_B = \frac{V_{CC} - V_{BE}}{R_b}$$

$$= \frac{9 - 0.7}{300 \times 10^3} = \frac{8.3}{300 \times 10^3} = 0.0277\,mA$$

$$I_C = 50 \times 0.0277 \times 10^{-3} = 1.385 \times 10^{-3}$$

$$= 1.385\,mA$$

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

$$= 9 - (1.385 \times 10^{-3})(1 \times 10^3)$$

$$= 7.615\,V$$

$\therefore$ Collector current $= 1.385\,mA$

Collector to emitter voltage $= 7.615\,V$

9. Determine current gain, input impedence and voltage gain of CE transistor amplifier is characteristzed by hie is 2K, hre is 2×10^{-4} hfe is 50 and hoe is 2×10^{-6} A/v if load resistance is 4kΩ and the source resistance is 200Ω

Sol: Given $h_{ie} = 2k\Omega$

$h_{re} = 2\times10^{-4}$

$h_{fe} = 50$

$h_{oe} = 20\times10^{-6}$ A/V

$R_L = 4k\Omega$

$R_S = 200\Omega.$

current gain $(A_i) = \dfrac{-h_{fe}}{1+h_{oe}R_L} = \dfrac{-50}{1+(20\times10^{-6})(4\times10^{3})}$

$= \dfrac{-50}{1.08} = -46.29$

Input impedence $(Z_i) = h_i - \dfrac{h_r h_f R_L}{1+h_o R_L}$

$= 2\times10^{3} - \dfrac{(2\times10^{-4})(50)(4\times10^{3})}{1+(20\times10^{-6})(4\times10^{3})}$

$= 2\times10^{3} - 37.03$

$= 1962.97\Omega$

Voltage gain $(A_V) = \dfrac{-h_f R_L}{h_i + R_L \Delta h}$

$\Delta h = h_o h_i - h_r h_f = (20\times10^{-6})(2\times10^{3}) - (2\times10^{-4})(50)$

$= 0.03$

$A_V = \dfrac{-(50)(4\times10^{3})}{(2\times10^{3}) + (4\times10^{3})(0.03)} = \dfrac{200000}{2120} = 94.33$

10. Draw the DC load line and locate the operating point for fixed biasing transistor values $R_B = 820k\Omega$ $R_C = 4.7k\Omega$ $V_{CC} = 15V$ and $\beta = 120$

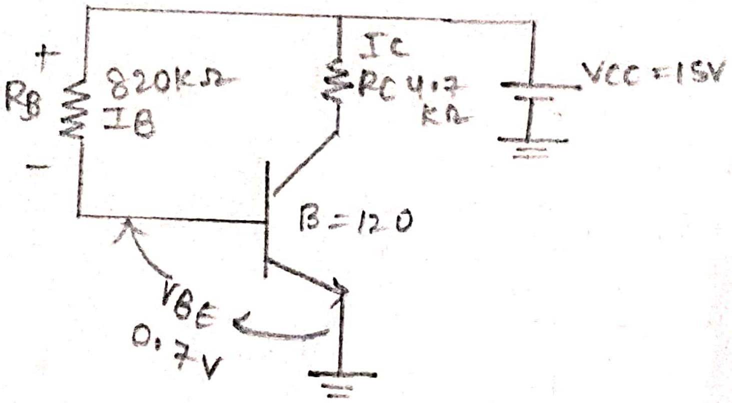
Sol: Given $R_B = 820k\Omega$

$R_C = 4.7k\Omega$

$V_{CC} = 15V$

$\beta = 120$

Circuit diagram:



$$V_{CC} - i_B R_B - V_{BE} = 0$$

$$i_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{15 - 0.7}{820 \times 10^3} = \frac{14.3}{820 \times 10^3} = 17.44 \times 10^{-6}$$

$$i_C = \beta I_B = 120 \times (17.44 \times 10^{-6}) = 2.09 \times 10^{-3}$$

$$= 2.09mA$$

$$i_{CQ} = 2.09mA$$

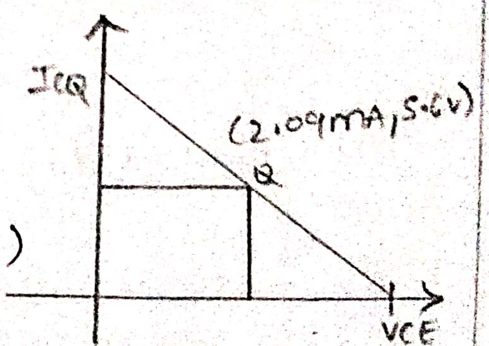
$$V_{CC} - i_C R_C - V_{CE} = 0$$

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

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

$$= 15 - 9.4$$

$$V_{CEQ} = 5.6V$$



$S = 1 + \beta = 1 + 120$

$= 121$

1.B)

Calculate the input impedance, circuit input impedance and output impedance of a small signal amplifier with unbypassed emitter resistor of h_{fe} is 100, h_{ie} is 560 and R_C is 2k and R_B is 600k

Sol:- Given data :-

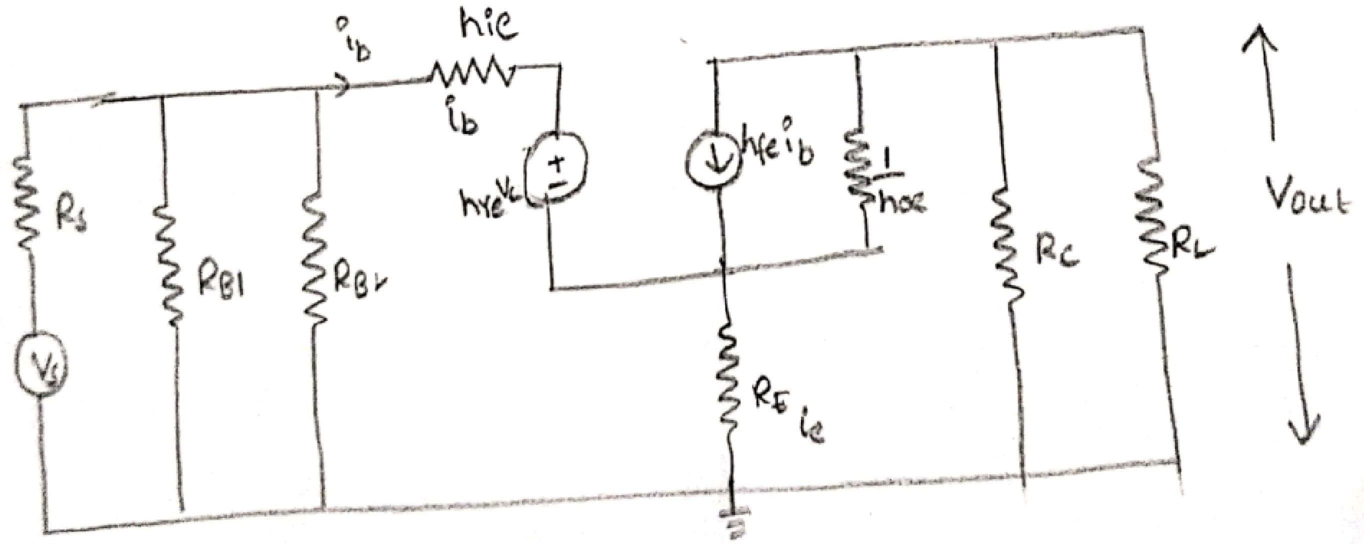
$h_{fe} = 100$

$h_{ie} = 560$

$R_C = 2K\Omega$

$R_B = 600K\Omega$

Circuit diagram:-



1) input impedance (R_{in}):-

$$R_{in} = h_{ie} + R_E(1+\beta) \quad [\because R_E = 0]$$

$$R_{in} = h_{ie}$$

$$R_{in} = 560\Omega$$

2) circuit Input impedance:-

$$Z_{in} = R_B \parallel R_{in}$$

$$= \frac{R_B R_{in}}{R_B + R_{in}}$$

$$= \frac{(600 \times 10^3)(560)}{(600 \times 10^3) + 560}$$

$$Z_{in} = 559.5\Omega$$

3) output impedance :-

$$Z_{out} = R_C$$

$$Z_{out} = 2k\Omega$$

3b) Determine the input resistance, current gain and voltage gain of a CE transistor amplifier has the following characteristics h_{ie} is 1000, h_{fe} is 50, h_{re} is 2.5×10^{-4} and h_{oe} is 25×10^{-6} A/V if the load resistance is R_L is 10K and source Resistance R_s is 100.

Sol:-

Given data:-

$h_{ie} = 1000\Omega$

$h_{fe} = 50$

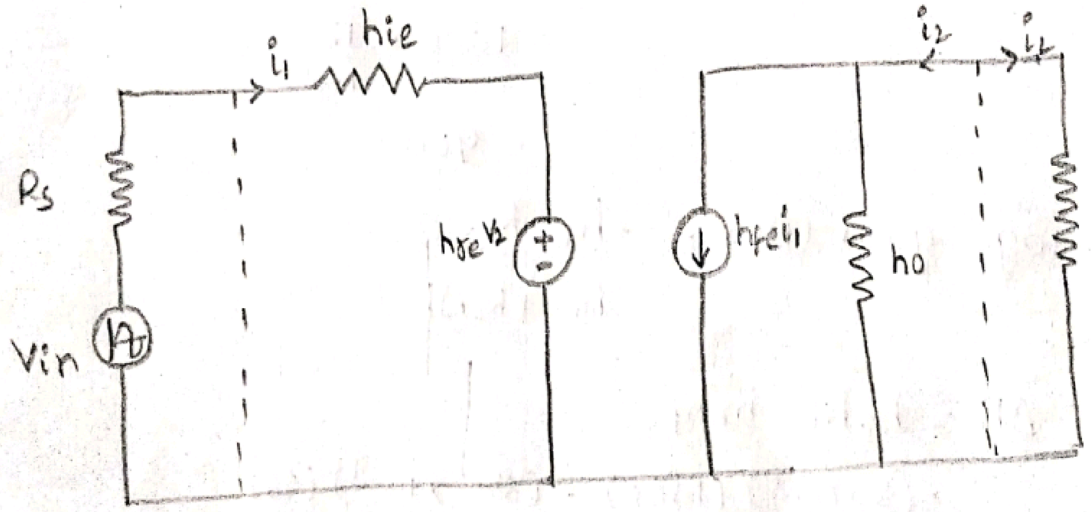
$h_{re} = 2.5\times10^{-4}$

$h_{oe} = 25\times10^{-6}$ A/V

$R_L = 10K$

$R_S = 100\Omega$

Circuit diagram:-



Formulas:-

$$\text{Current gain } (A_i) = \frac{-h_{fe}}{1+h_{oe}R_L}$$

$$\text{input resistance } (Z_i) = h_i - \frac{h_r h_f R_L}{1+h_o R_L}$$

output

$$\text{voltage gain } (A_v) = -\frac{h_{fe} R_L}{h_{ie} + R_L \Delta h}$$

1) current gain $(A_i) = \dfrac{-h_{fe}}{1 + h_{oe} R_L}$

$$= \frac{-50}{1 + (25\times10^{-6})(10\times10^{3})}$$

$$= -40$$

2) Input impedance $(Z_i) = h_i - \dfrac{h_r h_f R_L}{1 + h_o R_L}$

$$= 1000 - \frac{(2.5\times10^{-4})(50)\times(10\times10^{3})}{1 + (25\times10^{-6})(10\times10^{3})}$$

$$= 1000 - \frac{125}{1 + (250\times10^{-3})}$$

$$= 1000 - \frac{125}{1.25}$$

$$= 900$$

3) voltage gain $(A_v) = \dfrac{-h_{fe} R_L}{h_{ie} + R_L \Delta h}$

$\Delta h = h_o h_i - h_r h_f$

$= (25\times10^{-6})(1000) - (2.5\times10^{-4})(50)$

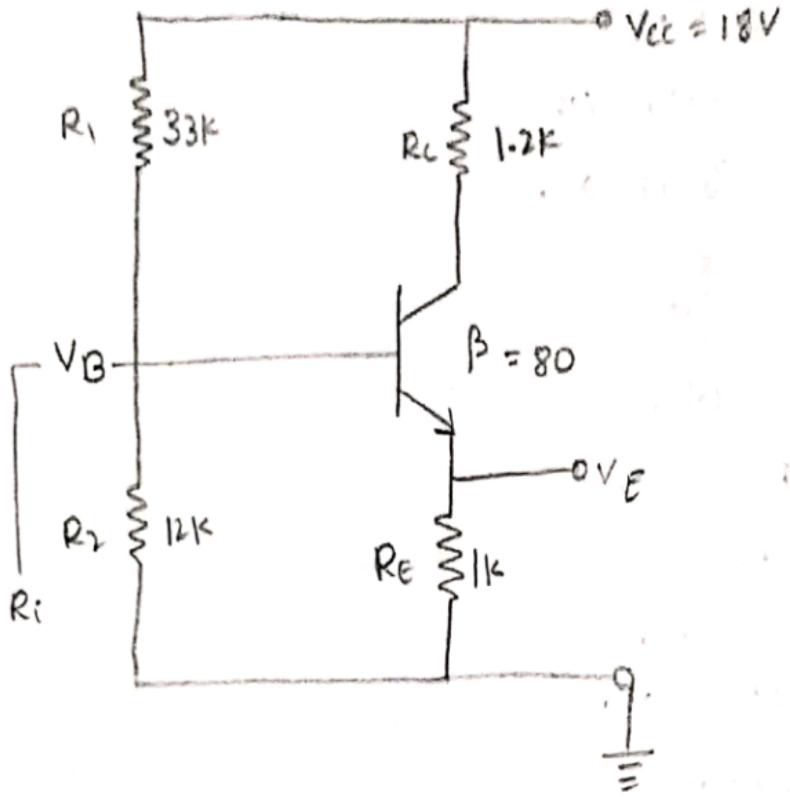
$= 0.025 - 0.0125$

$= 0.0125$

$$A_v = \frac{-(50)(10\times10^{3})}{1000 + (10\times10^{3})(0.0125)}$$

$$= -444.4$$

4a) Calculate the I_C, V_E, V_B, V_{CE}, R_{in} for the voltage divider bias circuit as shown in below.



Sol:- Given Data :-

$R_1 = 33K$

$R_2 = 12K$

$R_C = 1.2K$

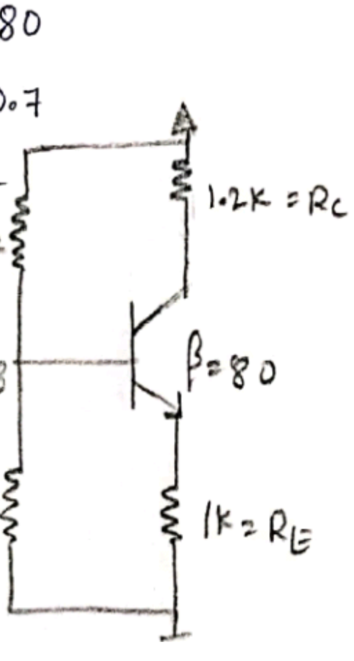
$R_E = 1K$

$V_{CC} = 18V$

$\beta = 80$

$V_{BE} = 0.7$

Circuit diagram :-



Formula

1) $$V_{BB} = \frac{R_2 V_{CC}}{R_1 + R_2}$$

$$= \frac{(12 \times 10^3)(18)}{(33+12) \times 10^3}$$

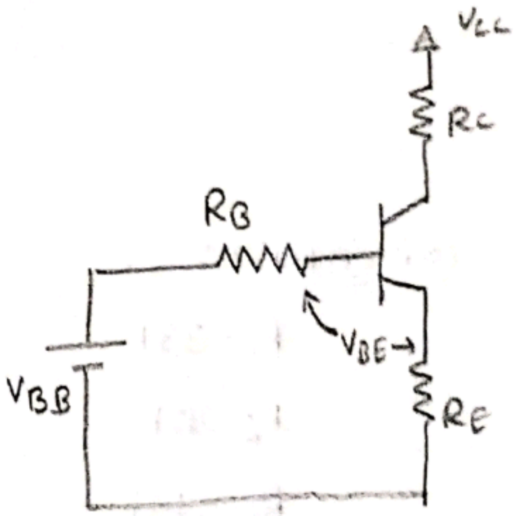
$$= \frac{216}{45}$$

$$= 4.8V$$

$$R_B = \frac{R_1 R_2}{R_1 + R_2}$$

$$= \frac{12 \times 33 \times 10^6}{(12+33) \times 10^3}$$

$$R_B = 8.8K\Omega$$



Loop Equation,

$$V_{BB} - V_{BE} - i_e R_E = 0$$

$$i_e = \frac{V_{BB} - V_{BE}}{R_E}$$

$$= \frac{4.8 - 0.7}{1 \times 10^3}$$

$$= 4.1 mAmp$$

We know that

$$\alpha = \frac{\beta}{1+\beta}$$

$$= \frac{80}{1+80}$$

$$\alpha = 0.98$$

$$\alpha = \frac{i_c}{i_e}$$

$$i_c = \alpha i_e$$

(2) $i_c = (0.98) \times (4.1)$

$\boxed{i_c = 4.01\,m.Amp}$

3) We know that

$V_E = i_e R_E$

$= 4.1 \times 10^{-3} \times 1 \times 10^{3}$

$\boxed{V_E = 4.1V}$

4) $V_{CE} =$

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

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

$V_{CE} = 18 - (4.01 \times 10^{-3})(1.2 \times 10^{3}) - (4.1 \times 10^{-3})(1 \times 10^{3})$

$= 18 - (4.81) - 4.1$

$V_{CE} = 9.088V$

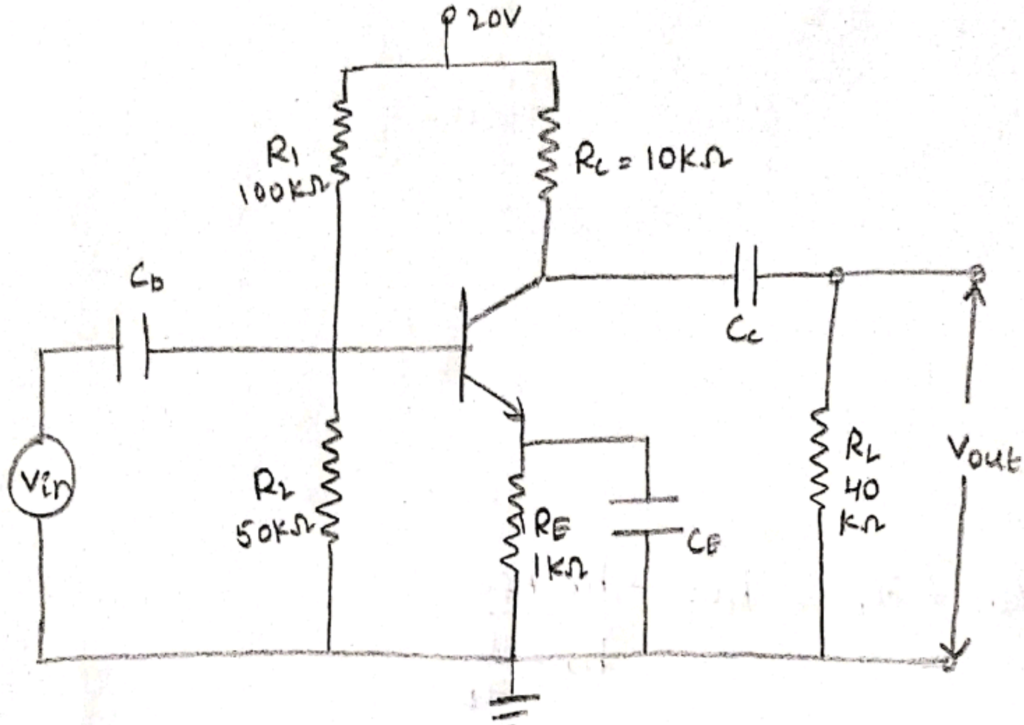
5)

$R_{in} = \beta R_E$

$= 80 \times 1 \times 10^{3}$

$R_{in} = 80k\Omega$

4b) Calculate Z_{in}, Z_{in} with biasing network and voltage gain of a BJT is given in following figure. The parameters are h_{ie} is 1500, h_{re} is 4×10^{-4} and h_{fe} is 100 and h_{oe} is 4×10^{-4} S



Sol:- Given Data:-

$R_1 = 100K\Omega$

$R_2 = 50K\Omega$

$R_E = 1K\Omega$

$R_L = 40K\Omega$

$R_C = 10K\Omega$

$h_{ie} = 1500$

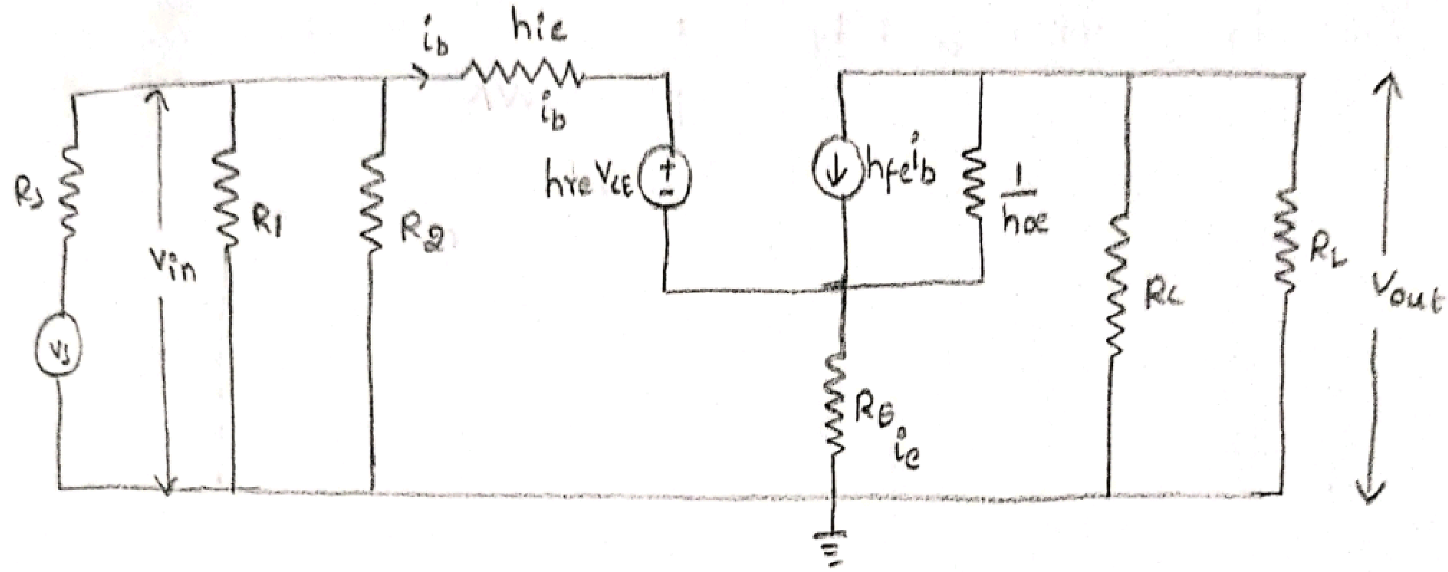
$h_{re} = 4\times10^{-4}$

$h_{fe} = 100$

$h_{oe} = 4\times10^{-4}$ S

Circuit diagram

Equivalent Circuit:-



Formulas:-

$$Z_{in} = Z_b = h_{ie} - \frac{h_{re}h_{fe}}{h_{oe} + \frac{1}{Z_L}}$$

$$Z_{feedback} = Z_b \| R_1 \| R_2$$

$$\text{voltage gain } (A_v) = -\frac{h_{fe}}{h_{ie}} (R_C \| R_L)$$

1) input impedance

$$Z_{in} = h_{ie} - \frac{h_{re}h_{fe}}{h_{oe} + \frac{1}{Z_L}}$$

$$= 1500 - \frac{4\times10^{-4}\times100}{4\times10^{-4} + \frac{1}{40\times10^{3}}}$$

$$= 1500 - \frac{4\times10^{-4}\times100}{4\times10^{-4} + 0.25\times10^{-4}}$$

$$= 1500 - \frac{400}{4.25}$$

$$Z_{in} = 1.405\,k\Omega$$

2) $Z_{feedback} = Z_b || R_1 || R_2$

$$R_1 || R_2 = \frac{R_1 R_2}{R_1 + R_2}$$

$$= \frac{100 \times 50 \times 10^6}{(100+50) \times 10^3}$$

$$= 33.33 k\Omega$$

$$Z_{feedback} = \frac{33.33 \times 10^3 \times 1.405 \times 10^3}{(33.33 + 1.405) \times 10^3}$$

$$= 1.348 k\Omega$$

3) Voltage gain (A_v):

$$A_v = \frac{-h_{fe}}{h_{ie}} (R_C || R_L)$$

$$= \frac{-100}{1500} \left[\frac{10 \times 40 \times 10^3 \times 10^3}{(10+40)\ 10^3} \right]$$

$$= -\frac{1}{15} \left[\frac{10 \times 40 \times 10^3}{50} \right]$$

$$= -533.3$$

$$A_v = -533.3$$

5b) Determine the input impedance, output impedance and voltage gain for the common base circuit values and parameters are $R_1 = 20K$, $R_2 = 5K$, $R_C = 8K$, $R_E = 4K$, $R_L = 6K$, $h_{ib} = 25$, $h_{ob} = 0.5 \times 10^{-6}$ A/v and $h_{fb} = -9.8$

Sol:- Given data:-

$R_1 = 20K$

$R_2 = 5K$

$R_C = 8K$

$R_E = 4K$

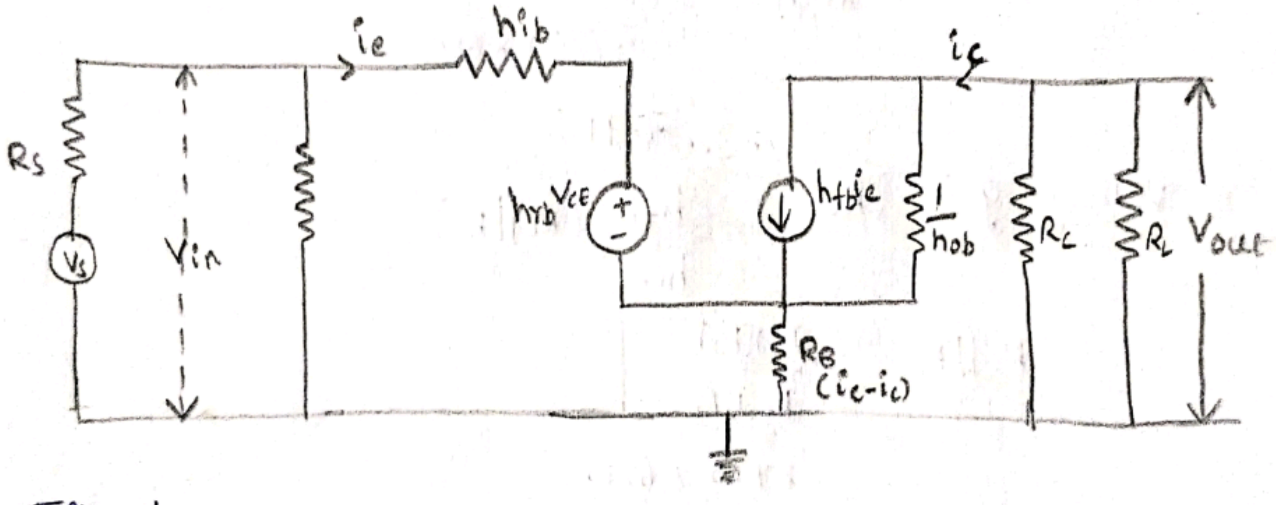
$R_L = 6K$

$h_{ib} = 25$

$h_{ob} = 0.5 \times 10^{-6}$ A/v

$h_{fb} = -9.8$

Circuit diagram:-



Formulas:-

Input impedance $(Z_{in}) = Z_E \| R_E$

Output impedance $(Z_{out}) = \frac{1}{h_{ob}} \| R_C$

Voltage gain $(A_V) = \frac{-h_{fb}}{h_{ib}} (R_C \| R_L)$

1) input impedance $(Z_{in}) = Z_E || R_E$

$$Z_{in} = \frac{Z_E\ R_E}{Z_E\ R_E} \qquad [\therefore Z_E = h_{ib}]$$

$$Z_{in} = \frac{25 \times 4 \times 10^3}{25 + (4 \times 10^3)}$$

$$= 24.8$$

2) output impedance $(Z_{out}) = \frac{1}{h_{ob}} || R_C$

$$\frac{1}{h_{ob}} = \frac{1}{0.5 \times 10^{-6}}$$

$$\frac{1}{h_{ob}} = 2 \times 10^6$$

$$Z_{out} = \frac{2 \times 10^6 \times 8 \times 10^3}{2 \times 10^6 + 8 \times 10^3}$$

$$= 7.9\ K\Omega$$

3) voltage gain $(A_V) = \frac{-h_{fb}}{h_{ib}} (R_C || R_L)$

$$R_C || R_L = \frac{(R_C)(R_L)}{R_C + R_L}$$

$$= \frac{8 \times 10^3 \times 6 \times 10^3}{14 \times 10^3}$$

$$= 3.428\ K\Omega$$

$$A_V = \frac{-(-9.8)}{25} (3.428\ K\Omega)$$

$$= (0.392)(3.428 \times 10^3)$$

$$= 1343$$

6b) Compute the Q-point (I_{DQ} and V_{DSQ}) and draw the DC load line of N-channel JFET has R_D is 2K I_{DSS} is 10mA and V_P is -4V when V_{GS} is -1.5V

Sol:- Given,

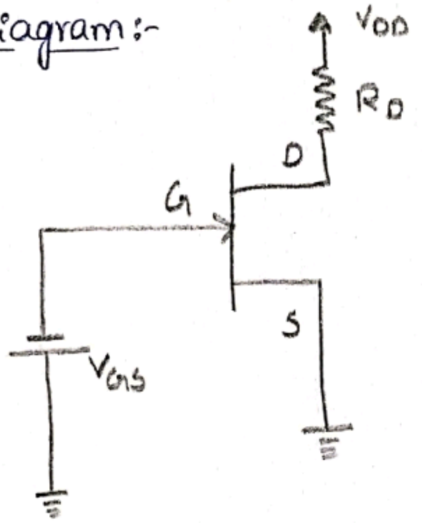
$R_D = 2K$

$I_{DSS} = 10mA$

$V_P = -4V$

$V_{GS} = -1.5V$

Circuit diagram:-



Formula:-

$$I_{DQ} = I_{DSSQ}\left[1 - \frac{V_{GS}}{V_P}\right]^2$$

$$= (10\times10^{-3})\left[1 - \frac{(-1.5)}{(-4)}\right]^2$$

$$= (10\times10^{-3})\left[1 - 0.375\right]^2$$

$$= (10\times10^{-3})\left[0.625\right]^2$$

$$= (10\times10^{-3})(0.3906)$$

$$= 3.906\times10^{-3}$$

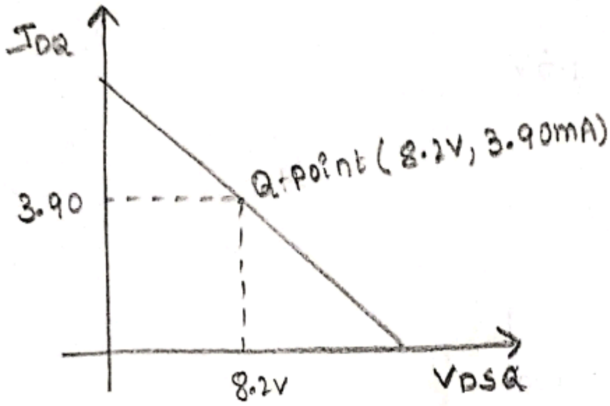
$$\boxed{I_{DQ} = 3.906mA}$$

$$V_{DSQ} = V_{DD} - I_{DD} R_Q$$

$$= 16 - (3.90 \times 10^{-3} \times 2 \times 10^{3})$$

$$= 16 - (3.90 \times 2)$$

$$\boxed{V_{DSQ} = 8.2V}$$



7b) Calculate the values of R_D and R_S of JFET amplifier circuit R_G is 500k, V_{GS} is -1V, V_{DS} is 4.0V and I_{DSS} is 1mA, V_{DD} is 10V.

Sol:- Given Data:-

$V_{DD} = 10V$

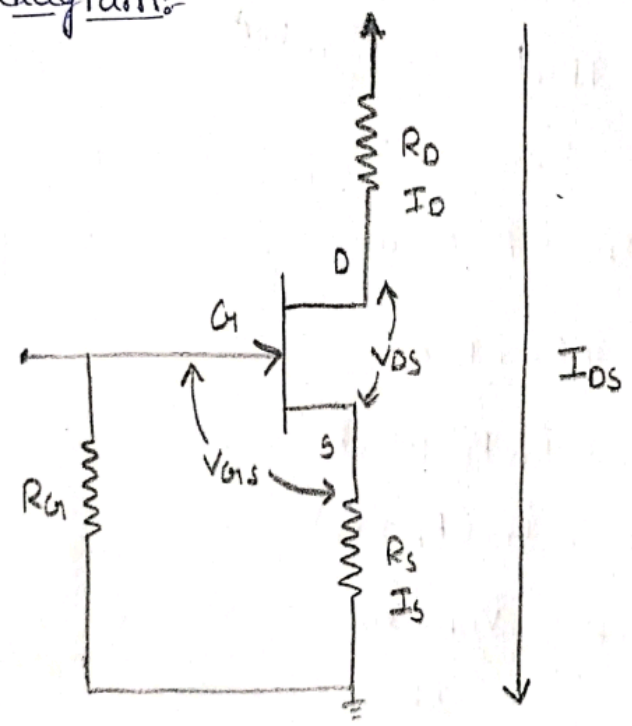
$V_{GS} = -1V$

$V_{DS} = 4V$

$I_{DS} = 1mA$

$R_G = 500k\Omega$

Circuit diagram:-



Now,

$V_{GS} = -1V$

$V_G - V_S = -1V$

We know that,

$V_G = i_G R_G$ $\quad [\because i_G = 0]$

$= i_G \times 500 \times 10^3$

$= 0 \times 500 \times 10^3$

$V_G = 0$

Now $V_G - V_S = -1V$

$$\boxed{V_S = 1V}$$

from ohm's law

$$V_S = i_S R_S$$

$$V_S = i_{ds} R_S$$

$$R_S = \frac{V_S}{i_{ds}}$$

$$= \frac{1}{1 \times 10^{-3}}$$

$$R_S = 1 \times 10^{3}$$

$$\boxed{R_S = 1 K\Omega}$$

from loop equation

$$V_{DD} - i_D R_D - V_{DS} - R_S i_S = 0$$

$$V_{DD} - V_{DS} = i_D R_D + R_S i_S$$

$$V_{DD} - V_{DS} = i_{ds} R_D + i_{ds} R_S$$

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

$$R_D + R_S = \frac{V_{DD} - V_{DS}}{i_{ds}}$$

$$R_D = \frac{V_{DD} - V_{DS}}{i_{ds}} - R_S$$

$$= \frac{10-4}{1 \times 10^{-3}} - (1 \times 10^{3})$$

$$= \frac{6}{1 \times 10^{-3}} - (1 \times 10^{3})$$

$$= (6 \times 10^{3}) - (1 \times 10^{3})$$

$$= 5 \times 10^{3}$$

$$\boxed{R_D = 5 K\Omega}$$

8b) calculate voltage gain AV and output resistance Ro of the common source amplifier, drain resistance (R_D) is 5K, amplification factor (μ) is 50 and r_d is 35K

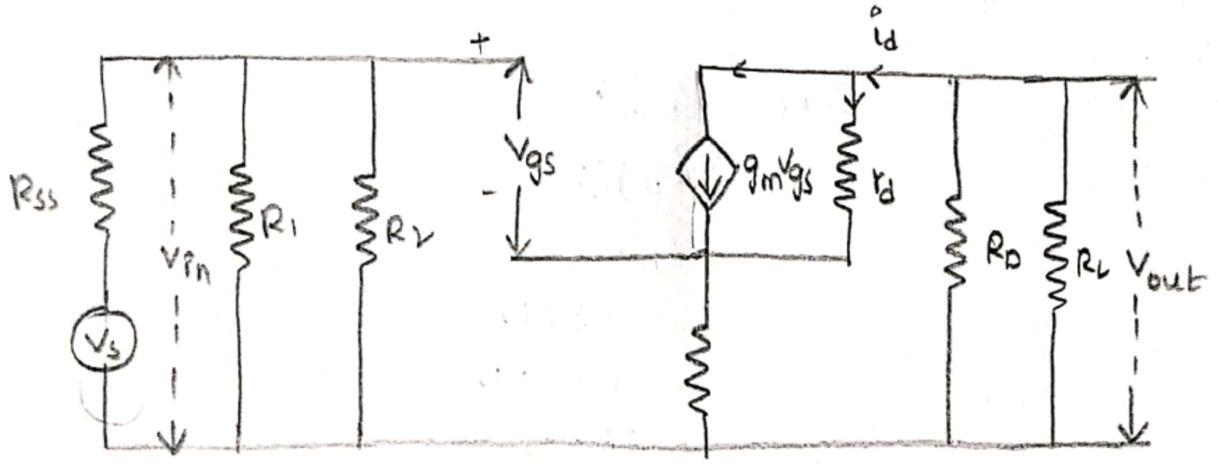
Sol:- Given data,

$R_D = 5K$

$r_d = 35K$

$\mu = 50$

Circuit diagram:-



Formulas:-

$$A_V = -g_m (r_d \| R_D)$$

output impedance $(R_o) = R_D \| r_d$

1) Voltage gain (A_V):

$$A_V = -g_m (r_d \| R_D)$$

$$= \frac{-g_m r_d R_D}{r_d + R_D}$$

$$= \frac{-\frac{\partial I_D}{\partial V_{GS}} \cdot \frac{\partial V_{DS}}{\partial I_D} R_D}{R_D + r_d}$$

$$= \frac{-\mu R_D}{R_D + r_d}$$

$$= \frac{-50 \times (5 \times 10^3)}{(5 + 35) \times 10^3}$$

$$= \frac{-250}{40}$$

$$\boxed{A_V = -6.25}$$

2) Output Resistance (R_o) :-

$$R_o = R_D \parallel r_d$$

$$= \frac{(R_D)(r_d)}{R_D + r_d}$$

$$= \frac{35 \times 5 \times 10^6}{(35+5) \times 10^3}$$

$$= \frac{175 \times 10^3}{40}$$

$$\boxed{R_o = 4.37 \, k\Omega}$$

9b) Determine the voltage gain of the amplifier of a JFET, The transconductance is for voltage 2,500 μS and load resistance is 12K. Assume r_d and $R_D << R_L$

Sol:- Given data:-

$$g_m = 2500 \mu S$$

$$R_L = 12 K\Omega$$

Formula:-

$$\text{Voltage gain}(A_v) = -g_m (r_d \| R_D \| R_L)$$

$$= -g_m R_L \qquad [\because R_L >> R_D]$$

$$= -(2500 \times 10^{-6})(12 \times 10^{3})$$

$$= -(2500) \times 10^{-3} \times 12$$

$$A_v = -30$$

10b) Calculate the input impedance, output impedance and voltage gain of the common drain amplifier R_1 is 4M, R_2 is 2M, R_S=2.5K and R_L is 25K and g_m is 2500 μS.

Sol:- Given Data:-

$$R_1 = 4 M\Omega$$

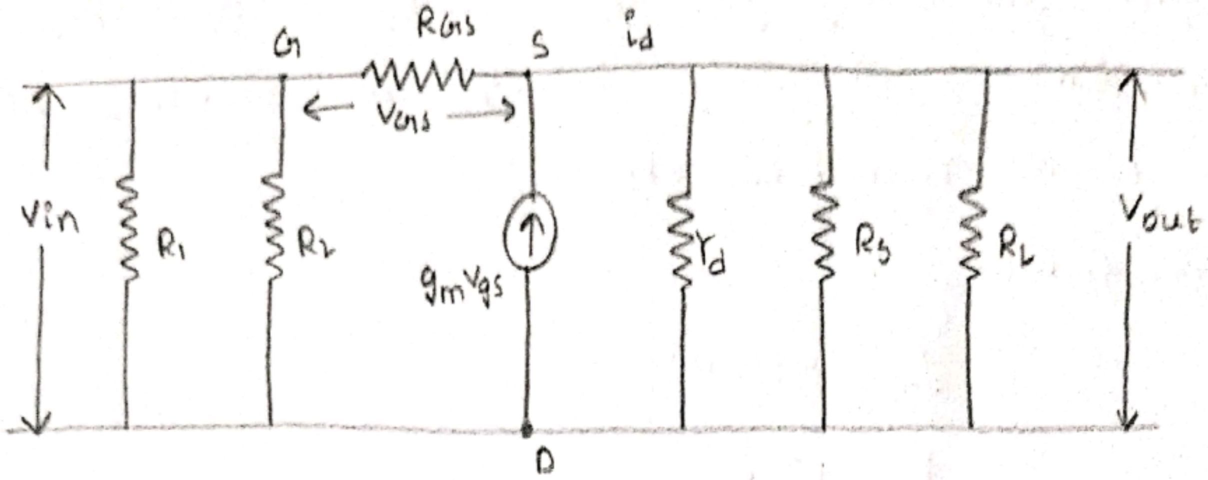
$$R_2 = 2 M\Omega$$

$$R_S = 2.5 K\Omega$$

$$R_L = 25 K\Omega$$

$$g_m = 2500 \mu S$$

Circuit diagram:-



Formulas:-

input impedance :-

$$R_G = \frac{R_1 R_2}{R_1 + R_2}$$

output impedance :-

$$R_{out} = R_S \parallel \frac{1}{g_m}$$

voltage gain (A_v): $\dfrac{g_m (R_S \parallel R_L)}{1 + g_m (R_S \parallel R_L)}$

1) Input impedance

$$R_G = \frac{R_1 R_2}{R_1 + R_2}$$

$$= \frac{4\times10^6 \times 2\times10^6}{(4+2)\times10^6}$$

$$= \frac{8\times10^6}{6}$$

$$R_G = 1.33 M\Omega$$

2) output impedance :-

$$R_{out} = R_S \parallel \frac{1}{g_m}$$

$$\frac{1}{g_m} = \frac{1}{2500\times10^{-6}}$$

$$= 400\,\Omega$$

$$\frac{1}{g_m} = 0.4K\Omega$$

$$R_{out} = \frac{2.5 \times 10^3 \times 0.4 \times 10^3}{(2.5+0.4) \times 10^3}$$

$$= \frac{2.5 \times 0.4 \times 10^3}{2.9}$$

$$R_{out} = 0.34K\Omega$$