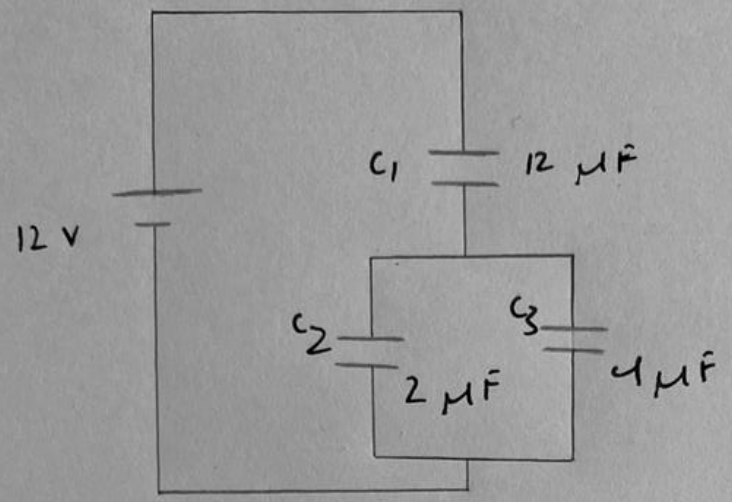
Question 1



$$C_{eq} = \left(\frac{1}{12} + \frac{1}{2+4}\right)^{-1}$$

$$= \frac{12 \times 6}{12+6}$$

$$= 4\ \mu F$$

$$Q = C_{eq} \cdot V$$

$$= 4 \times 12$$

$$= 48\ \mu C$$

$$V_1 = \frac{Q}{C_1}$$

$$= \frac{48}{12}$$

$$= 4\ V$$

$$V_{23} = \frac{Q}{C_{23}}$$

$$= \frac{48}{6}$$

$$= 8\ V$$

$$Q_2 = C_2 V_{23}$$

$$= 2 \times 8$$

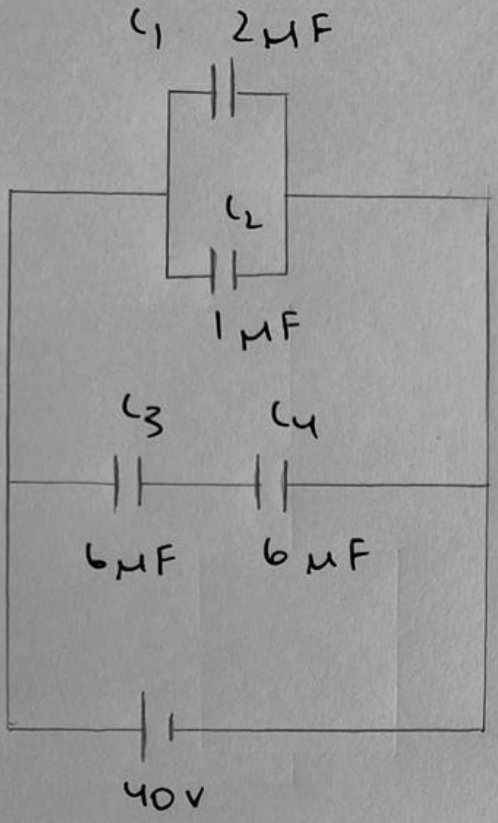
$$= 16\ \mu C$$

$$Q_3 = C_3 \cdot V_{23}$$

$$= 4 \times 8$$

$$= 32\ \mu C$$

Question 2



$C_{12} = 3\ MF$

$C_{34} = \frac{6^2}{2.6}$

$= 3\ MF$

$C_{eq} = C_{12} + C_{34}$

$= 6\ MF$

$Q = C_{eq} . V$

$= 6 . 40$

$= 240\ \mu C$

$V_{12} = V_{34} = 40V$

$Q_1 = C_1 V_{12}$

$= 2 \times 40$

$= 80\ \mu C$

$Q_2 = C_2 . V_{12}$

$= 1 \times 40$

$= 40\ \mu C$

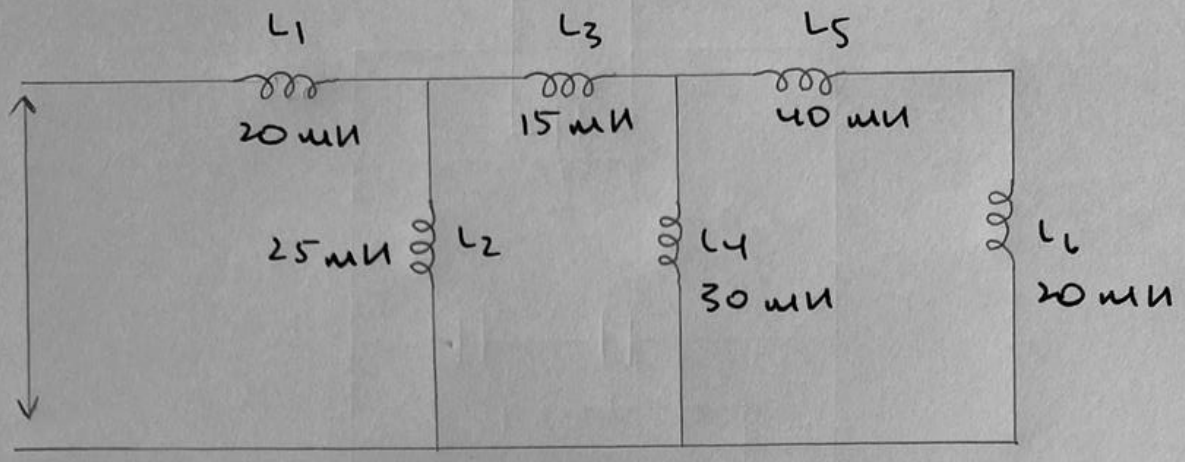
$Q_3 = Q_4 = Q_{34}$

$= C_{34} . V_{34}$

$= 3 \times 40$

$= 120\ \mu C$

Question 3



$L_{56} = L_5 + L_6$

$= 60\ mH$

$L_{456} = \frac{L_{56} \cdot L_4}{L_{56} + L_4}$

$= \frac{60 \times 30}{60 + 30}$

$= 20\ mH$

$L_{3456} = L_3 + L_{456}$

$= 15 + 20$

$= 35\ mH$

$L_{23456} = \frac{L_2 \times L_{3456}}{L_2 + L_{3456}}$

$= \frac{25 \times 35}{25 + 35}$

$= 14.538\ mH$

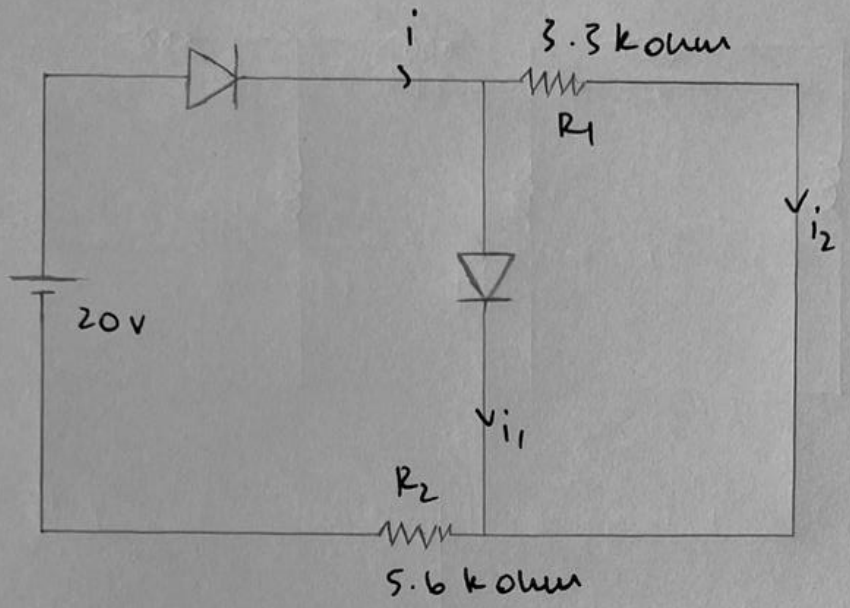
$L_{eq} = L_1 + L_{23456}$

$= 20 + 14.538$

$= 34.583\ mH$

Module 2

Question 1



$i_1 + i_2 = i$

$i_1 = i - i_2$

$\Rightarrow i_1 = 3.11 \text{ mA}$

Loop 1

$+20 - 0.7 - 0.7 - iR_2 = 0$

$\Rightarrow 4i = \frac{18.6}{R_2}$

$= 3.32 \text{ mA}$

Loop 2

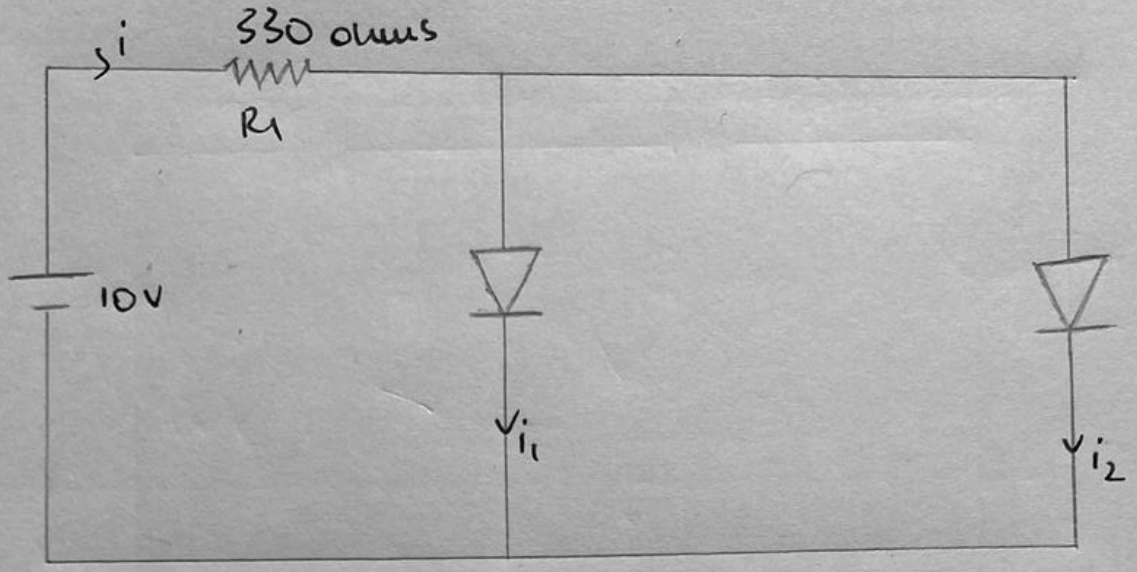
$+20 - 0.7 - R_1 i_2 - iR_2 = 0$

$\Rightarrow 19.3 - R_1 i_2 - iR_2 = 0$

$\Rightarrow i_2 = \frac{19.3 - iR_2}{R_1}$

$= 0.21 \text{ mA}$

Question 2



$i_1 + i_2 = i$

Loop 1

$10 - iR_1 - 0.7 = 0$

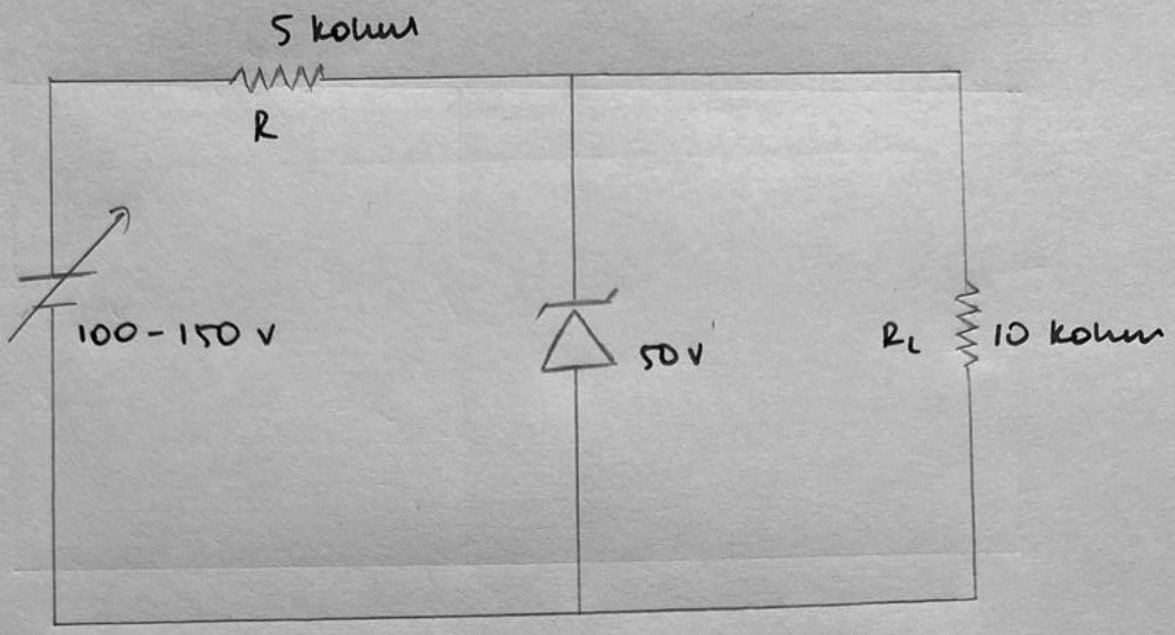
$\Rightarrow i = \frac{9.3}{R_1}$

$= \underline{28.18 \text{ mA}}$

$i_1 = i_2$ since potential drop is same between the diodes

$\therefore i_1 = i_2 = i/2 = \underline{14.09 \text{ mA}}$

Question 3



At E = 100 V

$$V_L = \frac{R_L \times E}{R + R_L}$$

$$= \frac{10 \times 100}{15}$$

$$= 66.67\ V \quad (> 50\ V)$$

$\therefore V_L = 50\ V, V_R = 50\ V$

$$I_2 = I_R - I_L$$

$$= \frac{50}{5 \times 10^3} - \frac{50}{10 \times 10^3}$$

$$= 5\ mA$$

At E = 150 V

$$V_L = \frac{R_L \times E}{R + R_L}$$

$$= \frac{10 \times 150}{15}$$

$$= 100\ V \quad (> 50\ V)$$

$\therefore$ Max $V_L = 50\ V, V_R = 100\ V$

$$I_2 = I_R - I_L$$

$$= \frac{100}{5 \times 10^3} - \frac{50}{10 \times 10^3}$$

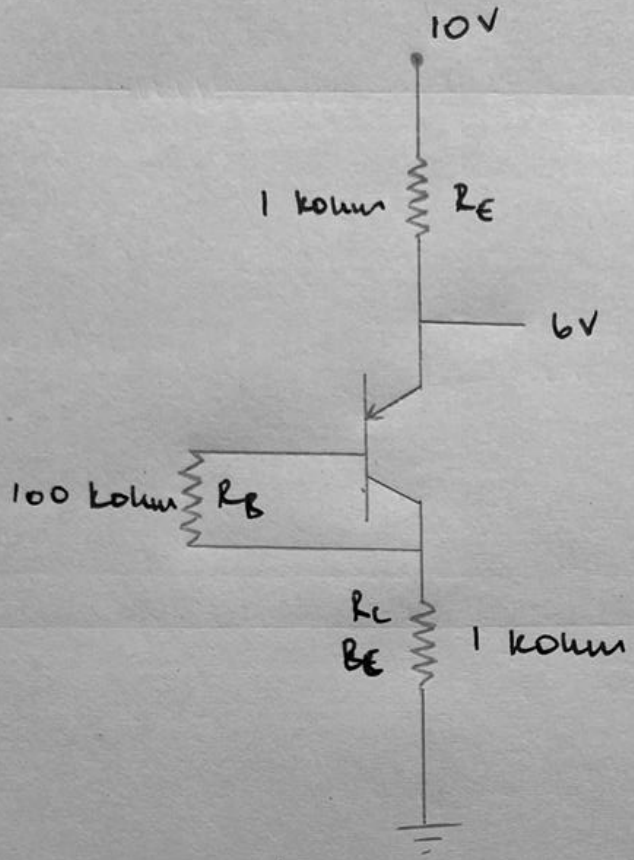
$$= 15\ mA$$

$\therefore$ Max current = 15 mA

Min current = 5 mA

Module 3

Question 1



$I_E R_E = 10 - 6$

$\Rightarrow I_E = \frac{4}{1 \times 10^3}$

$= 4 \text{ mA}$

$V_{BE} = 0.7V$

$I_C \simeq I_E$

$\therefore I_C = 4 \text{ mA}$

$V_L = I_C R_C$

$= 4 \times 1$

$= 4V$

$\therefore V_{CB} = 5.3 - 3$

$= 2.3V$

$I_B = \frac{V_{CB}}{R_B}$

$= \frac{2.3}{100}$

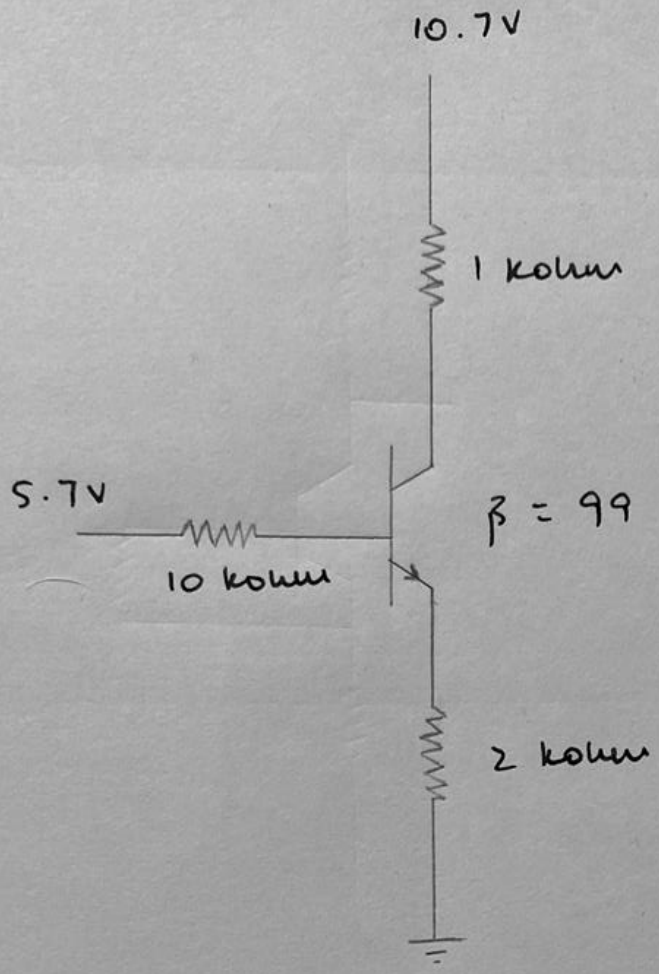
$= 0.023 \text{ mA}$

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

$= \frac{4}{0.023}$

$= 174$

Question 2



$5.7 - R_E I_E - V_{BE} - R_B I_B = 0$

$V_{BE} = 0.7V$

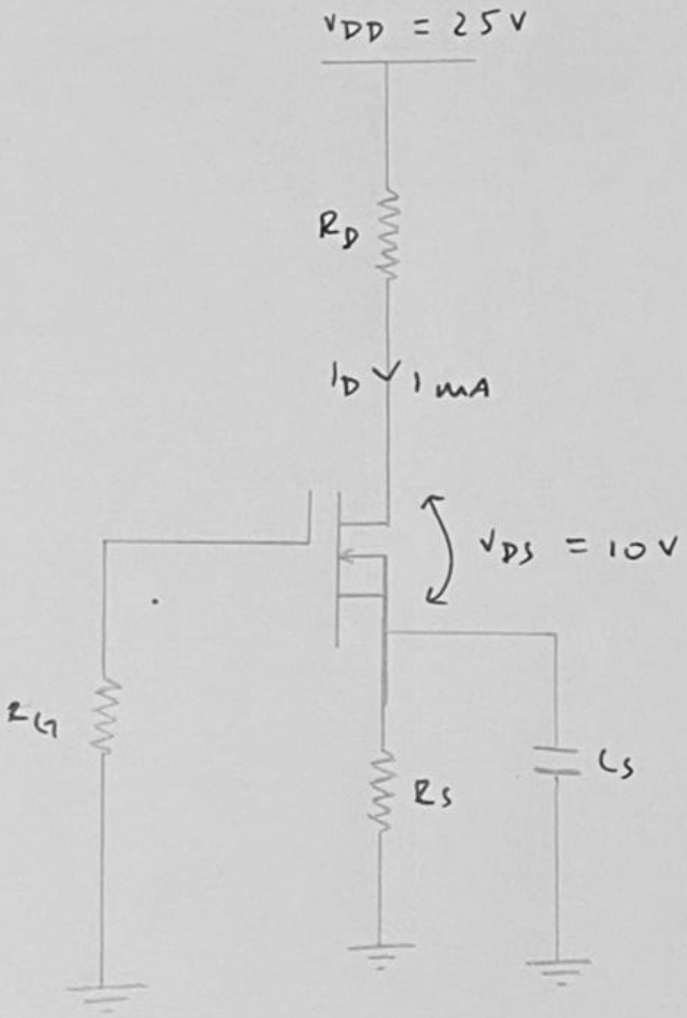
$I_E = (\beta + 1) I_B$

$\therefore 5.7 - 2(100).I_B - 0.7 - 10 I_B = 0$

$\Rightarrow I_B = \frac{5}{210}$

$\Rightarrow I_B = 0.0238 \text{ mA}$

Question 3



$V_{GS(off)} = -3\,V$

$I_{DSS} = 4\,mA$

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

$$\Rightarrow V_{GS} = V_{GS(off)}\left[\left(\frac{I_D}{I_{DSS}}\right)^{1/2} - 1\right]$$

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

$$= -1.5\,V$$

$V_{DSL} =$

$V_{GS} = V_G - V_S$

$\Rightarrow V_S = V_G - V_{GS} = 1.5\,V$

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

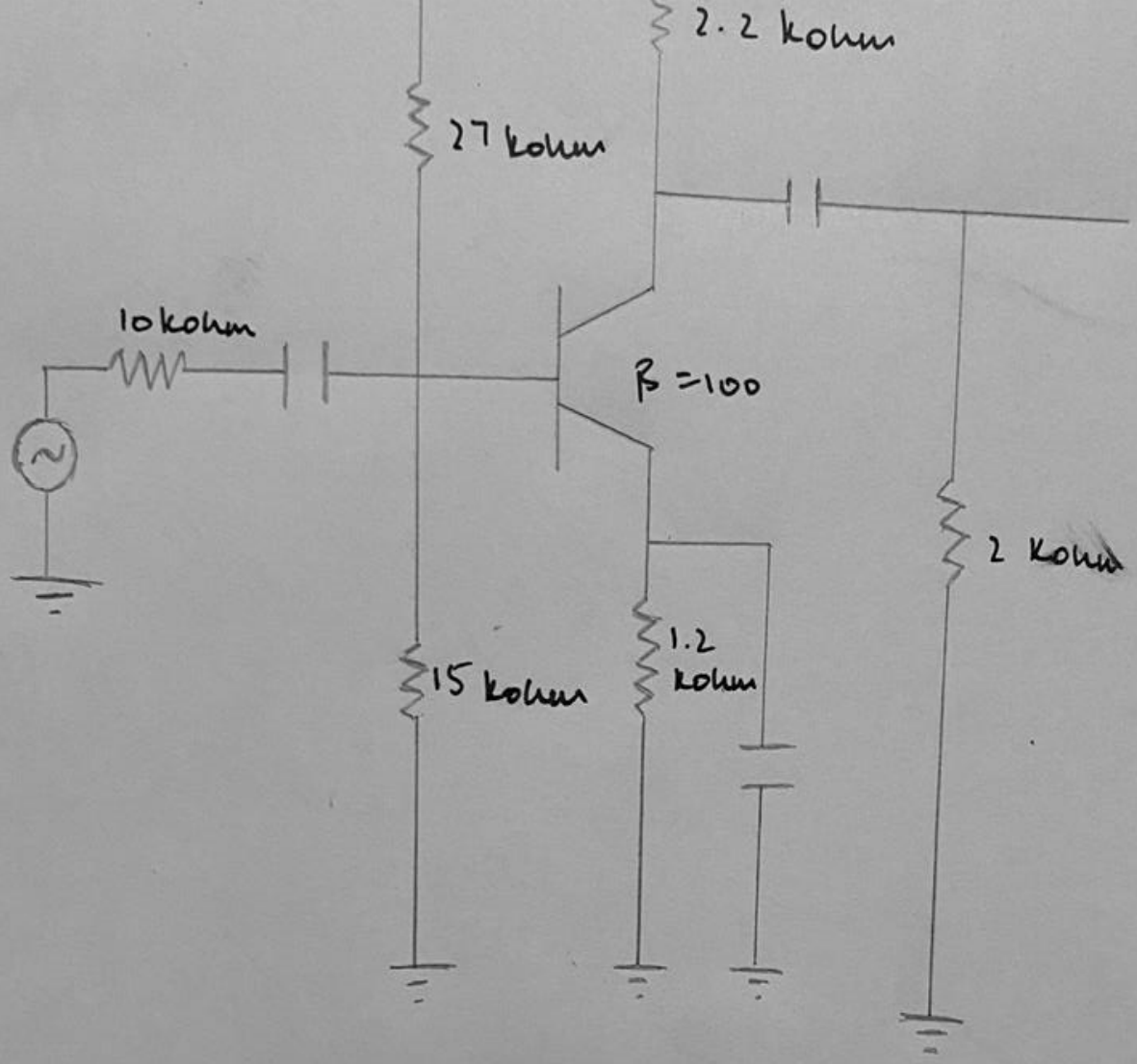
$$= \frac{1.5}{10^{-3}}$$

$$= 1500 \text{ ohms}$$

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

$$\Rightarrow 25 - R_D - 10 - 1.5 = 0$$

$$\Rightarrow R_D = 13.5 \text{ kohm}$$



$$V_B = \frac{15}{15+27} \times 9$$

$$= 3.21\ V$$

$$R_B = \left(\frac{1}{15} + \frac{1}{27}\right)^{-1}$$

$$= 9.64\ \text{kohm}$$

$$V_B - I_B R_B - V_{BE} - I_E R_E = 0$$

$$\Rightarrow V_B - I_B R_B - V_{BE} - (\beta+1) I_B R_E = 0$$

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

$$= \frac{3.21 - 0.7}{9.64 + (101).(1.2)}$$

$$= 0.019\ mA$$

$$I_L = \beta I_B$$

$$= 1.9\ mA$$

Question 2

$A = 5$ $\quad z_{in} = 200$

$P = 5\,mW$

$V_{DD} = 5\,V$

$V_T = 0.5\,V$

$\mu_n C_{ox}\left(\frac{W}{L}\right) = 8\,mA/V^2$

$\lambda = 0$

$$I_D = \frac{P}{V}$$

$$= \frac{5\,mW}{5\,V}$$

$$= 1\,mA$$

$$I_D = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)(V_{GS} - V_T)^2$$

$$\Rightarrow V_{GS} = \sqrt{\frac{2I_D}{\mu_n C_{ox}\left(\frac{W}{L}\right)}} + V_T$$

$$\Rightarrow V_{GS} = 1\,V$$

$$g_m = \frac{2I_D}{V_{GS} - V_T}$$

$$= \frac{2 \times 1\,mA}{0.5}$$

$$= 4\,m.mho$$

$$A = g_m \cdot R_D$$

$$\Rightarrow R_D = \frac{5}{4}$$

$$= 1.25\,K\,ohm$$

$$z_{in} = \frac{\frac{1}{g_m} \cdot R_S}{\frac{1}{g_m} + R_S}$$

$$\Rightarrow R_S = \frac{1}{1/z_{in} - g_m}$$

$$= \left[\frac{1}{1/200 - 4 \times 10^{-3}}\right]\ \Omega$$

$$= 1\,K\,ohm$$

Question 3

Hartley oscillator

$C = 1\ pF = 10^{-12}\ F$

$f = 1\ MHz = 10^6\ Hz$

$M_v = 0.2$

$$\frac{L_2}{L_1} = M_v$$

$$\Rightarrow L_1 = 5L_2$$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$\Rightarrow L = \left(\frac{1}{2\pi f}\right)^2 \cdot \frac{1}{C}$$

$$\Rightarrow L_1 + L_2 = \left(\frac{1}{2\pi \cdot 10^6}\right)^2 \cdot 10^{12}$$

$$= \underline{25.3\ mH}$$

$$\therefore L_1 = \underline{21.11\ mH}$$

$$L_2 = \underline{4.22\ mH}$$

Module 5

Question 1

Binary – 100101101.1001001

To Hexadecimal

0001 0010 1101 . 1001 0010

= 1 2 D . 9 2

$= 12D.92_{16}$

To Decimal

$1 \times 16^2 + 2 \times 16 + 13 + 9 \times \frac{1}{16} + 2 \times \frac{1}{16^2}$

$= 256 + 32 + 13 + \frac{9}{16} + \frac{1}{128}$

$= 301.5703125_{10}$

To octal

100 101 101 . 100 100 100

$= 455.444_8$

Question 2

$$X = \bar{A}B\bar{C} + A\bar{B}\bar{C} + \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}\bar{C}$$

Simplify

$$X = \bar{A}B\bar{C} + A\bar{B}\bar{C} + \bar{A}\bar{B}\bar{C}$$

$$= \bar{A}B\bar{C} + \bar{B}\bar{C}(A + \bar{A})$$

$$= \bar{A}B\bar{C} + \bar{B}\bar{C}$$

$$= \bar{C}(\bar{B} + B\bar{A})$$

$$= \bar{C}(\bar{B} + \bar{A})$$

$$= \underline{\bar{A}\bar{C} + \bar{B}\bar{C}}$$

Question 3

$F = ABCD + ABC\bar{D} + \bar{A}B\bar{C}D + \bar{A}\bar{B} + AB\bar{C}$

Express in nand gates

$F = ABC(D + \bar{D}) + \bar{A}(\bar{B} + B\bar{C}D) + AB\bar{C}$

$= ABC + \bar{A}(\bar{B} + \bar{C}D) + AB\bar{C}$

$= ABC + \bar{A}\bar{B} + \bar{A}\bar{C}D + AB\bar{C}$

$= AB(C + \bar{C}) + \bar{A}(\bar{B} + \bar{C}D)$

$= AB + \bar{A}(\bar{B} + \bar{C}D)$