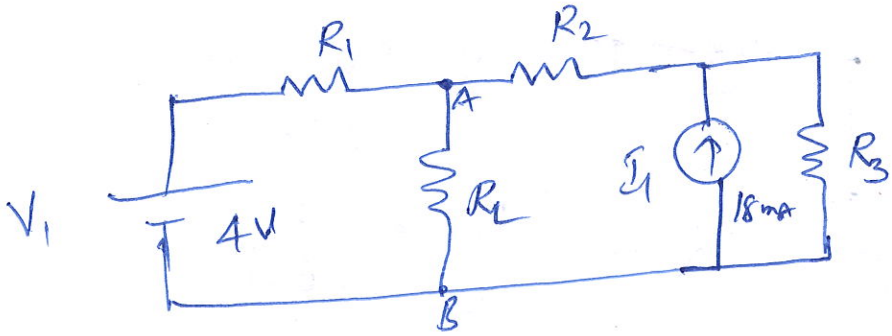
EECE 105L END SEMESTER EXAM

1) For the circuit shown below, calculate the value of R_L (in $k\Omega$) such that the power delivered to the resistor is maximized

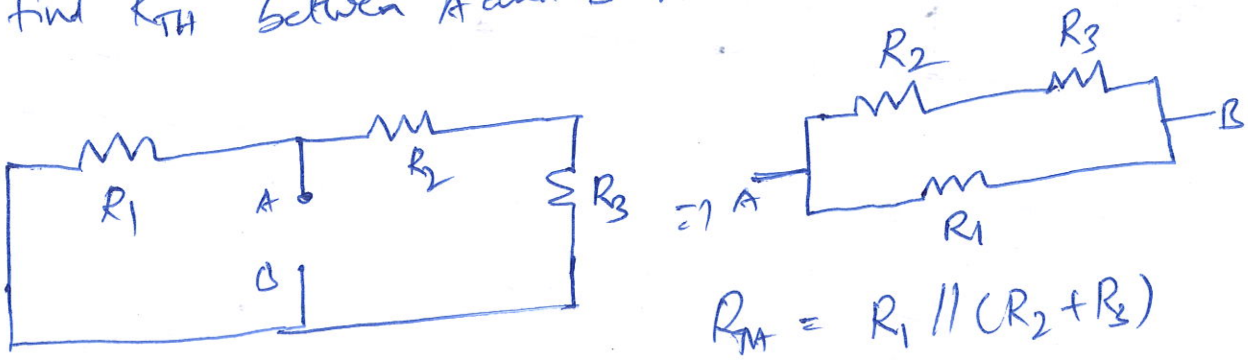


$R_2 = 7\,k\Omega$

$R_3 = 9\,k\Omega$

$R_L = 2\,k\Omega$

To find R_{TH} between A and B nodes:



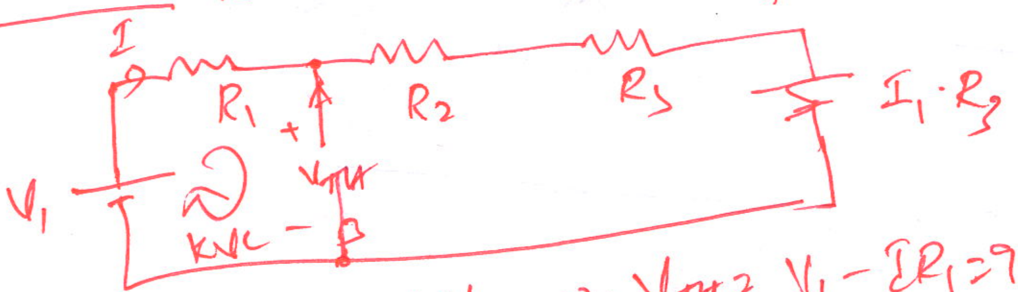
$R_{TH} = R_1 \parallel (R_2 + R_3)$

$R_{TH} = R_L = 2\,k\Omega = R_1 \parallel (16\,k\Omega)$

$\frac{1}{2} = \frac{1}{R_1} + \frac{1}{16}$ $\quad \frac{1}{R_1} = \frac{1}{2} - \frac{1}{16} = \frac{14}{2\times16}$

$R_1 = \frac{16}{7}\,k\Omega$

To find V_{TH}: Use source transformation.



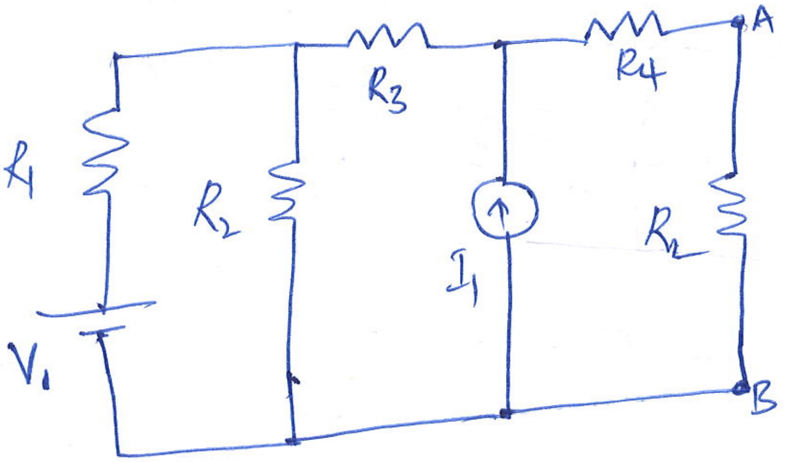
$I = \frac{4 - 18m \times 9\times10^{3}}{\left(\frac{16}{7} + 7 + 9\right)k} = -8.64\,mA$

KVL $V_1 = IR_1 + V_{TH} \Rightarrow V_{TH} = V_1 - IR_1 = \frac{95}{4}\,V$

$R_L = R_{TH} = 2\,k\Omega$ $\quad P_{R_L} = \frac{V_{TH}^2}{4R_L} = \underline{70.51\,mW}$

2) $E_g = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{594 \times 10^{-9} \times 1.6 \times 10^{-19}} = \underline{2.092 \text{ eV}}$

3) For the circuit given below, find the voltage across the current source I_1.



$V_1 = 5V$
$I_1 = 0.3A$
$R_1 = 66\,\Omega$
$R_2 = 146\,\Omega$
$R_3 = 239\,\Omega$
$R_4 = 89\,\Omega$
$R_L = 282\,\Omega$

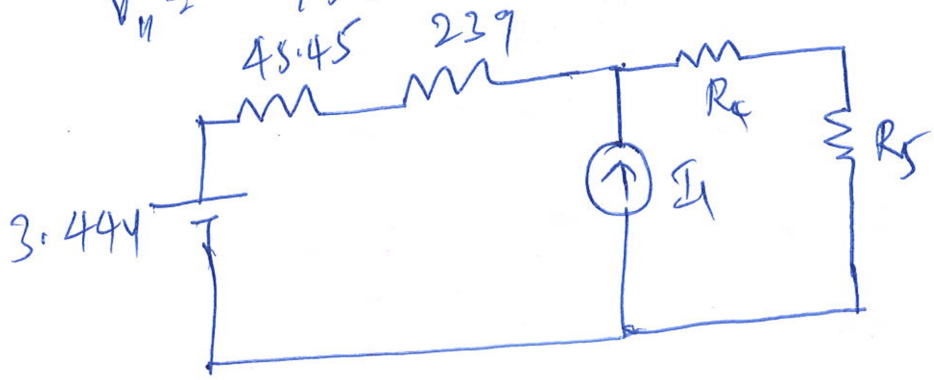
Source transformation between V_1, R_1:

$I_{11} = \frac{5}{66} = 75.76 \text{ mA}$

$R_1 \| R_2 = \frac{66 \times 146}{66 + 146} = 45.45\,\Omega$

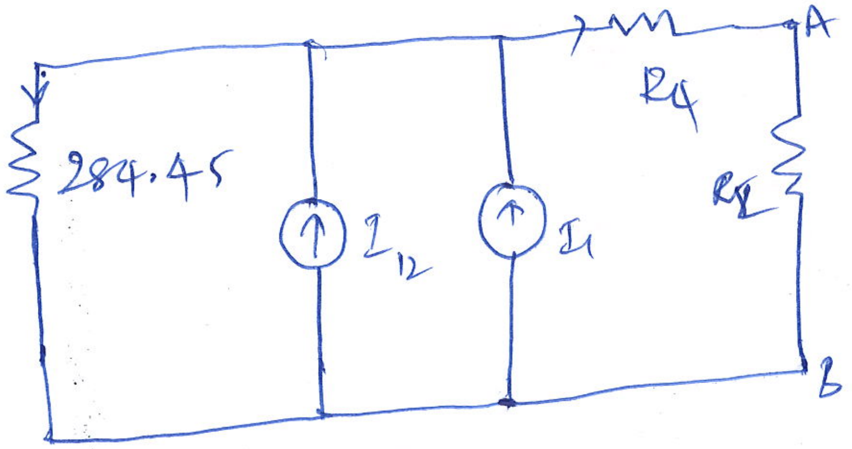
} Source transformation

$V_{11} = 75.76 \times 45.45 \times 10^{-3} = 3.44V$



Source Transformation:

$I_{12} = \frac{3.44}{45.45 + 239} = 12.10 \text{ mA}$



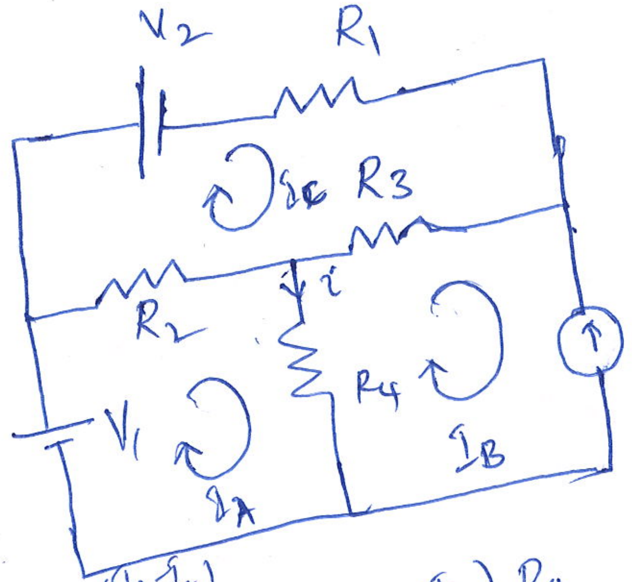
$R_4 + R_5 = 371\,\Omega$

$I_1 + I_2 = 0.3121\ A$

$I_{R4+R5} = 0.3121 \times \frac{284.45}{371 + 284.45} = 0.135A$

$V_{R4+R5} = V_{I_1} = 0.135 \times 371 = 50.25V$

4)



$i = \frac{?}{}$ mA

$R_1 = 7k\Omega \quad R_3 = 7k\Omega$

$R_2 = 4k\Omega \quad R_4 = 4k\Omega$

$V_1 = 8V \quad V_2 = 6V$

$I_1 = 4\,mA$

$I_B = -I_1 = -4\,mA$

$V_1 = (I_A - I_C)R_2 + (I_A - I_B)R_4$

$-V_2 = I_C R_1 + (I_C - I_B)R_3 + R_2(I_C - I_A)$

$8 = 4I_A - 4I_C + 4I_A + 4\cdot 4$

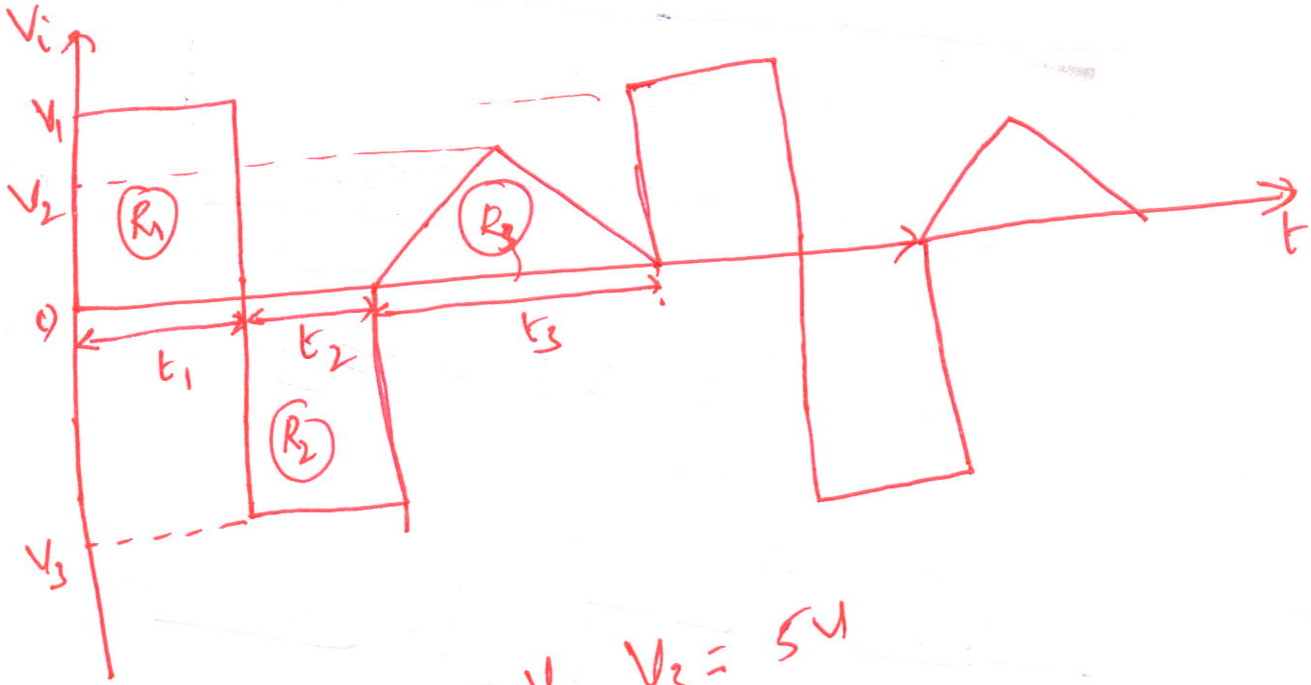
$8I_A - 4I_C = -8$ — (1)

$-4I_A + 18I_C = -6 - 28 = -34$ — (2)

$I_A = \frac{-35}{16}$ mA $\quad I_C = \frac{-17}{8}$ mA

$i = I_A - I_B = \frac{-35}{16} + 4 = \underline{1.8125 \text{ mA}}$

3)



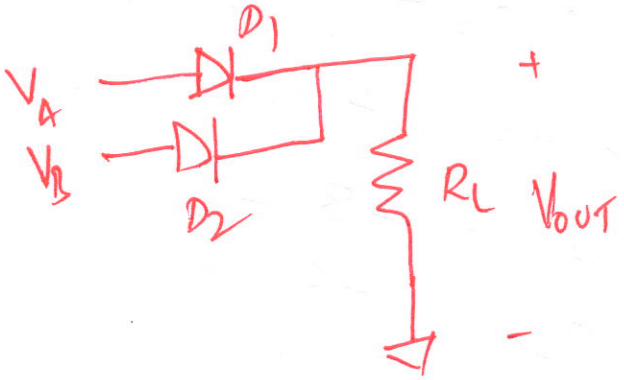
$V_1 = 12$ V $\quad V_2 = 4$ V $\quad V_3 = 5$ V

$t_1 = 6$ s $\quad t_2 = 3$ s $\quad t_3 = 6$ s.

Avrg Value $= \frac{12 \times 6 + (-5) \times 3 + \frac{1}{2} 4 \times 6}{6+3+6} = 4.6$ V

Peak Amplitude $= 12 - 4.6 = \underline{7.4 \text{ V}}$

6)



$R_L = 1240\,\Omega$

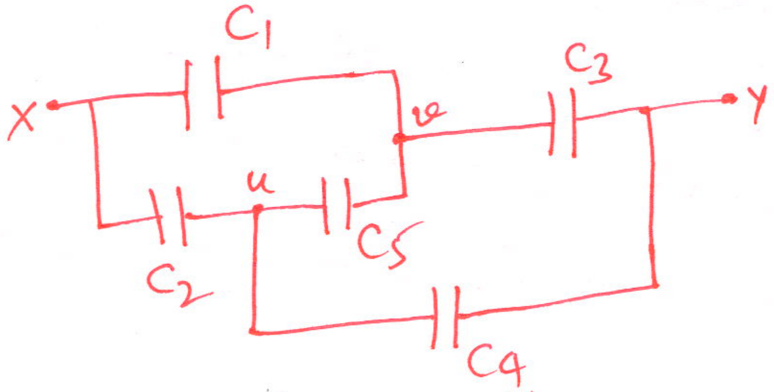
$V_A = 9.6$ V

$V_B = 7.7$ V

$$I_R = \frac{9.6 - 0.3 + 7.7 - 0.3}{1240} = 13.47\ mA$$

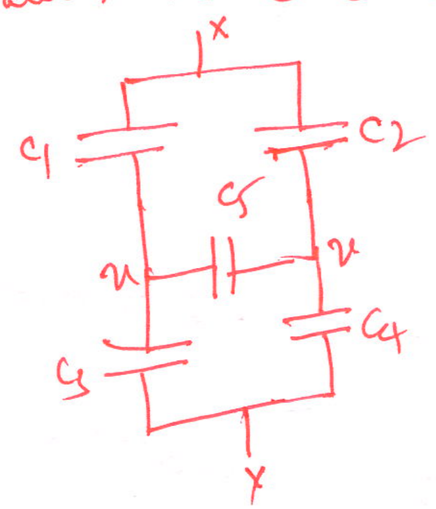
7) $$f_C = \frac{R}{2\pi L} \Rightarrow L = \frac{R}{2\pi f_C} = \frac{3.3\ k\Omega}{2\pi \times 54\ kHz} = \underline{9.73\ mH}$$

8)

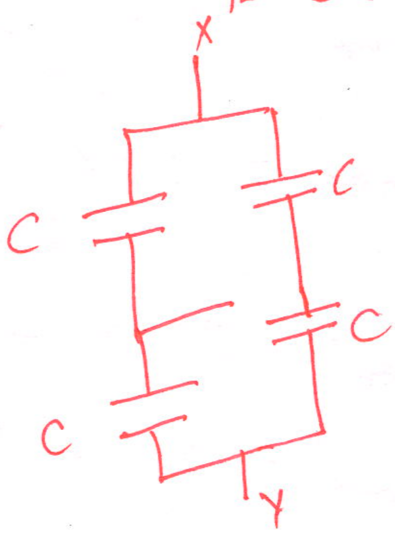


$C_i = C$

redrawing the circuit,



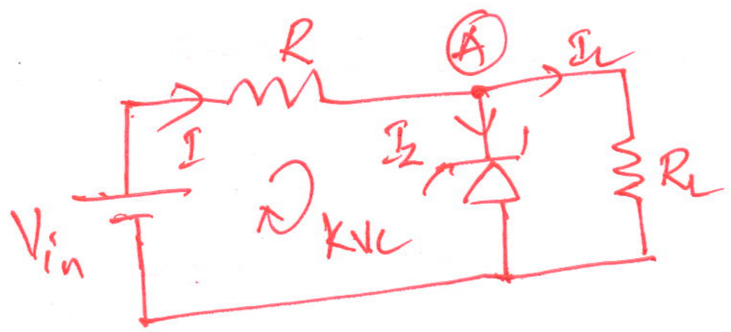
Since $C_i = C$, u, v acts like open. redrawing the circuit,



$\Rightarrow C_{XY} = C$

$C = 123\ \mu F$

9)



$R_L = 5\,k\Omega$

$V_Z = 53\,V$

$V_L = V_Z = 53\,V \quad I_L = \frac{V_L}{R_L} = \frac{53}{5k} = 10.6\,mA$

$V_{in,min} = 178\,V$

$V_{in,max} = 232\,V$

Applying KVL at node A,

$I = I_Z + I_L$

I_{Zmax} happens when I is max., when V_{in} is max.

I_{Zmin} happens when I is min, when V_{in} is min.

Applying KVL,

$V_{in} = IR + V_Z$

$I = \frac{V_{in} - V_Z}{R} =$

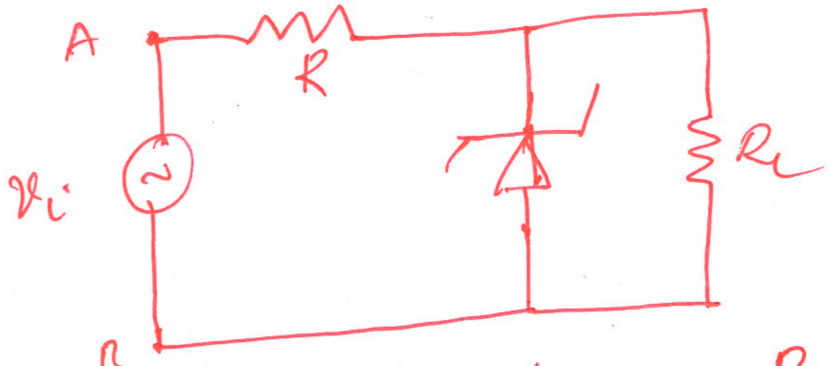
$I_{max} = \frac{178 - 53}{6k} = 20.833\,mA$

$I_{max} = \frac{232 - 53}{6k} = 29.833\,mA$

$I_{Zmax} = 29.833 - 10.6 = 19.23\,mA$

$I_{Zmin} = 20.833 - 10.6 = 10.23\,mA$

10)

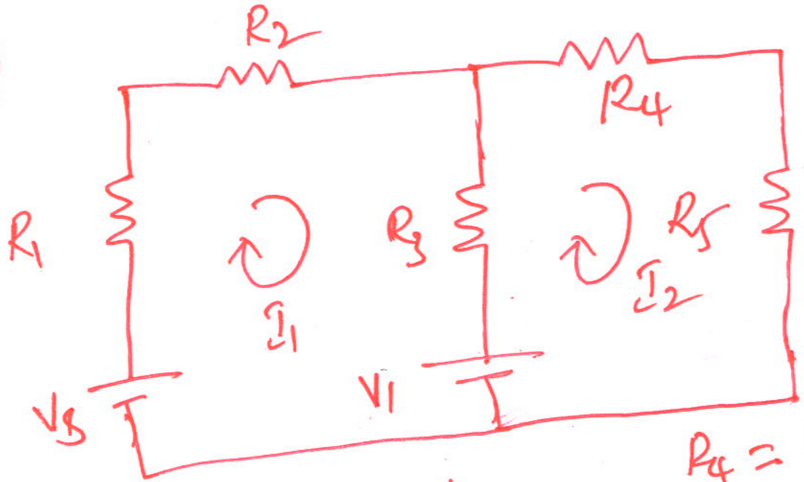


$v_i = 19.3 \sin(\omega t)$ $\quad R << R_L$

negative ~~Positive~~ half cycle, $V_{R_L} = 0.7V$

positive ~~Negative~~ half cycle, $V_{R_L} = V_z = \underline{3.7V}$

11)



$I_2 = 11\,mA$

$R_1 = 1412\,\Omega$

$R_2 = 748\,\Omega$

$R_3 = 2234\,\Omega$

$R_4 = 3492\,\Omega$ $\quad R_5 = 1384\,\Omega$

$V_1 = 26V$

In loop (Mesh 1);

$$V_s = I_1 R_1 + I_1 R_2 + R_3(I_1 - I_2) + V_1$$

$$4394 I_1 - 24.574 + 26 = V_s$$

$$4394 I_1 + 1.426 = V_s \quad -(1)$$

In Mesh 2,

$$V_1 = R_3(I_2 - I_1) + I_2(R_4 + R_5)$$

$$26 = 78.21 - 2234 \cdot I_1$$

$I_1 = 23.37\,mA$ (2)

Substituting I_1 in eq (1), $V_s = 104.114V$

~~V = 113.88~~

Power : $\underline{2433\,mW}$