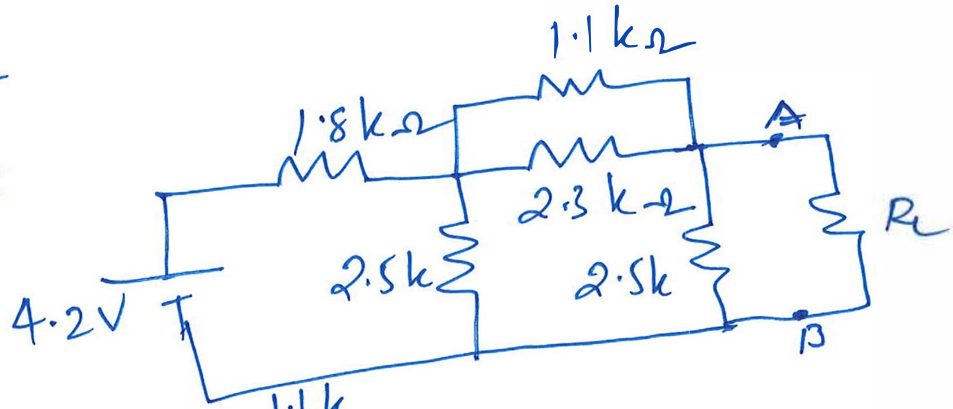
TUTORIAL SHEET-5

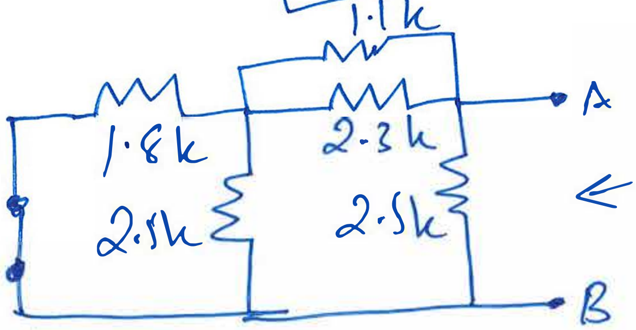
SOLUTIONS

1 & 2

Fig. 1

R_{TH}:



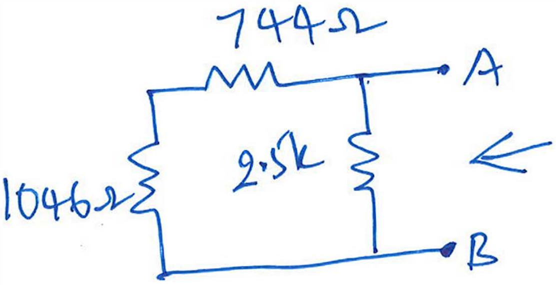


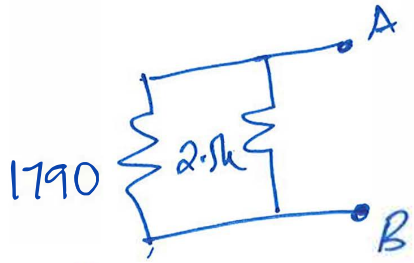
$1.1k \parallel 2.3k$

$= 744\,\Omega$

$1.8k \parallel 2.5k =$

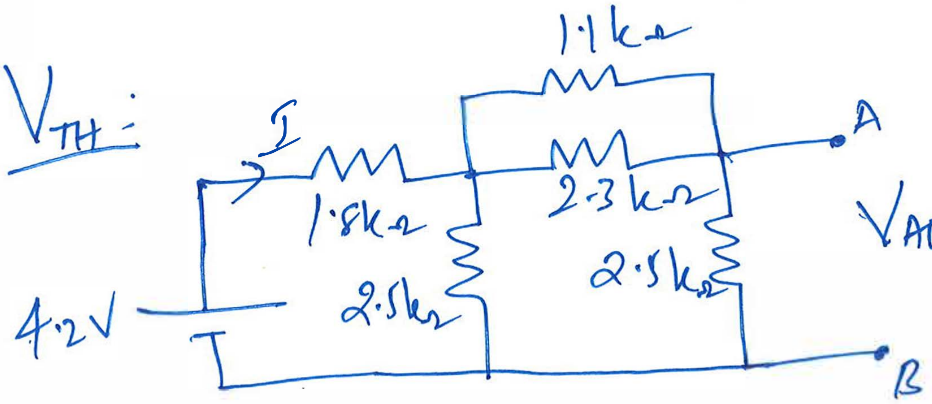
$= 1046\,\Omega$



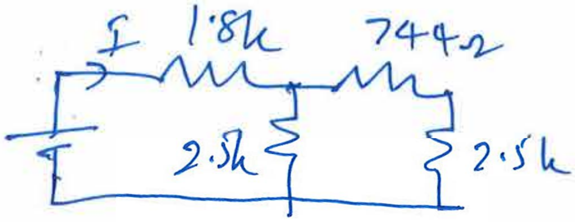


$R_{AB} = 1043\,\Omega = R_{TH}$

V_{TH}:

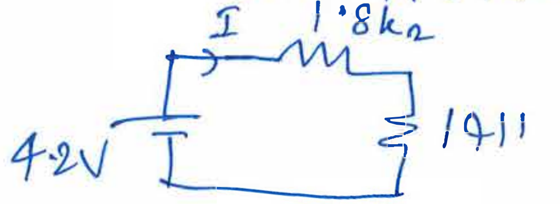


$V_{AB} = V_{TH}$

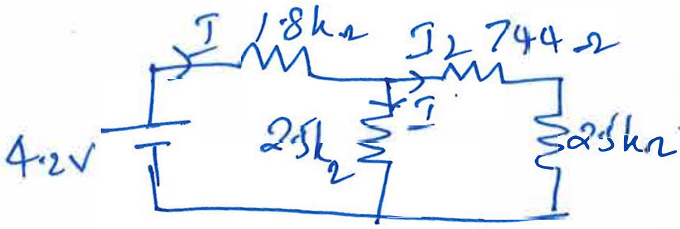


(2)

$2.5k \,||\, (744 + 2.5k) = 1411\,\Omega$



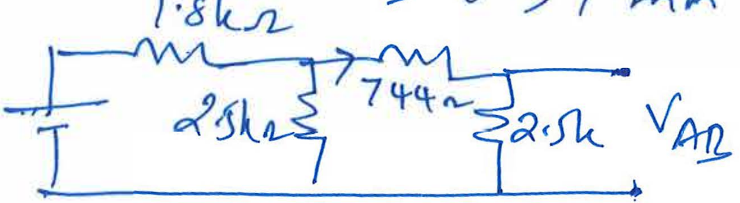
$$I = \frac{4.2}{1800 + 1411} = \underline{1.31\,mA}$$



~~I3~~ = 188

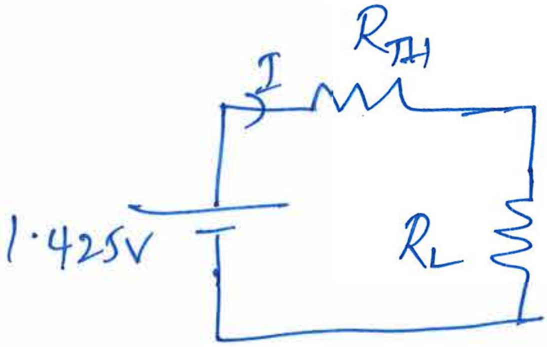
$$I_2 = 1.31\,mA \times \frac{2.5k}{2.5k + (744 + 2.5k)}$$

$$= 0.57\,mA$$



$V_{2.5k\Omega} = V_{AB} = 2.5k\Omega \times 0.57\,mA = \underline{1.425\,V}$

$V_{TH} = V_{AB} = 1.425\,V$



$R_{TH} = 1.043\,k\Omega$

Maximum power is transferred when $R_L = R_{TH}$.

Thus $R_L = 1.043\,k\Omega$

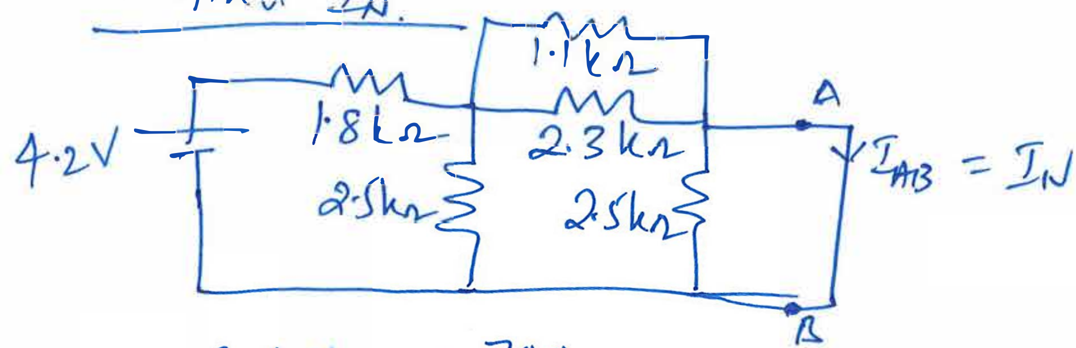
$$I_L = \frac{1.425}{R_L + R_{TH}} = 0.683\,mA$$

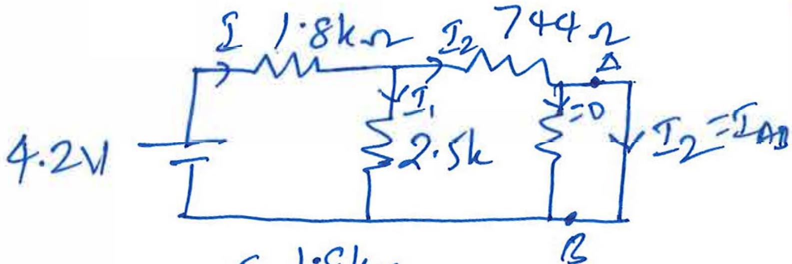
$V_L = 0.7125\,V$ $\quad P_L = V_L I_L = \underline{0.49\,mW}$

THEOREM

$R_{TH} = R_N = 1043\,\Omega$

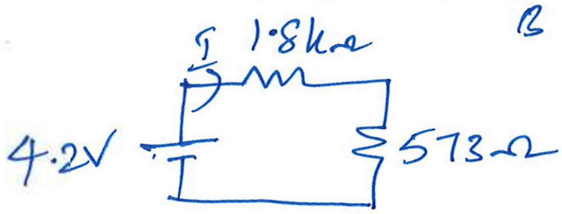
To find I_N:





$2.5k \| 744$

$573\,\Omega$



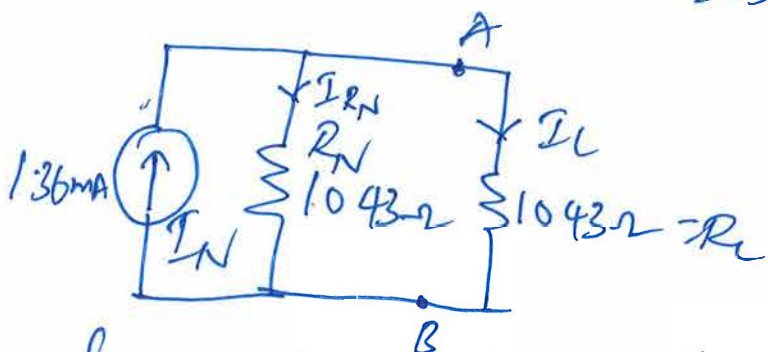
$I = 1.77\,mA$

$$I_{AB} = I_2 = \frac{1.77m \times 2.5k}{2500 + 744} = \cancel{1.404\,mA}$$

$1.36\,mA$.

$$I_1 = \frac{1.77m \times 744}{2500 + 744} = 0.4059$$

$\sim \underline{0.41\,mA}$

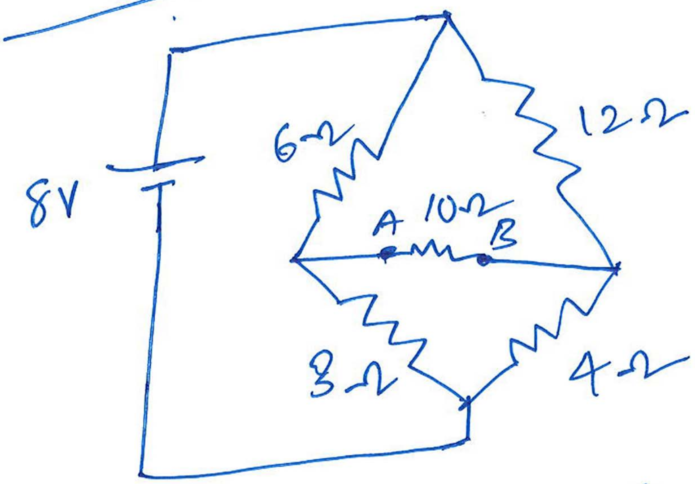


for maximum power transfer $R_L = R_N$

$$I_L = \frac{1.36\,mA \times R_L}{R_L + R_N} = 0.68\,mA$$

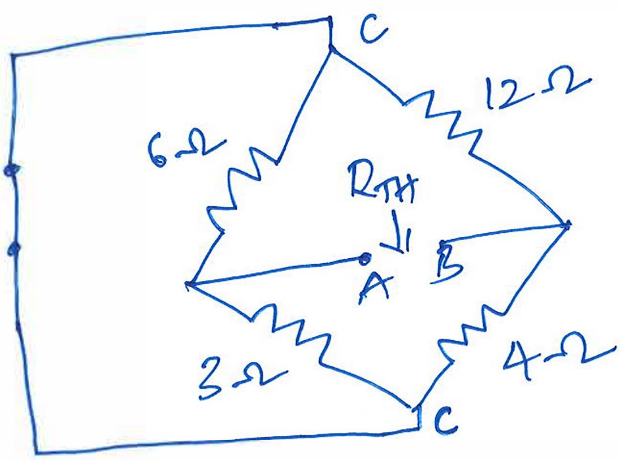
$V_L = 0.71\,V \quad P_L = I_L R_L = \underline{0.48\,mW}$

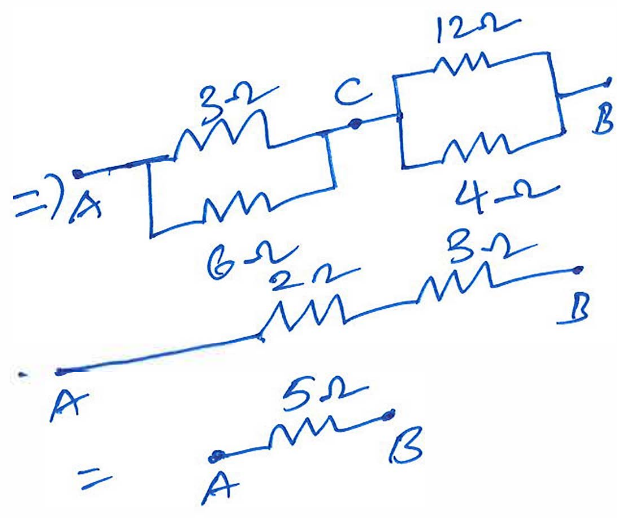
Fig. 2



THEVENIN's Equivalent

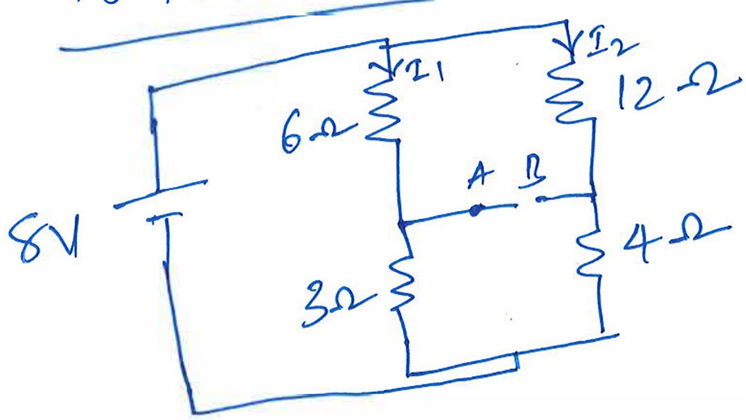
To find R_{TH}.





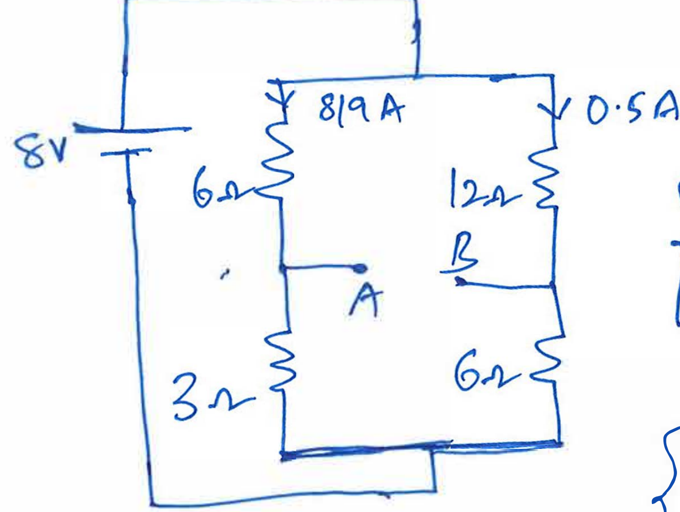
$R_{AB} = R_{TH} = 5\,\Omega$

To find V_{TH}



$$I_1 = \frac{8}{6+3} = \frac{8}{9}\,A$$

$$I_2 = \frac{8}{12+4} = 0.5A$$



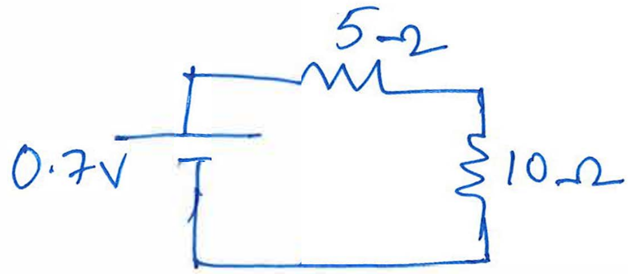
3

Voltage across 6Ω = 5.33V
Voltage across 3Ω = 2.67V

Voltage across 12Ω = 6V
Voltage across ~~8Ω~~ = 2V

Let the bottom 3Ω and 6Ω are connected to ground. Then $V_A = 2.67\,V$ $V_B = 2\,V$

$V_{AB} = 2.7 - 2 = \underline{0.67\,V}$



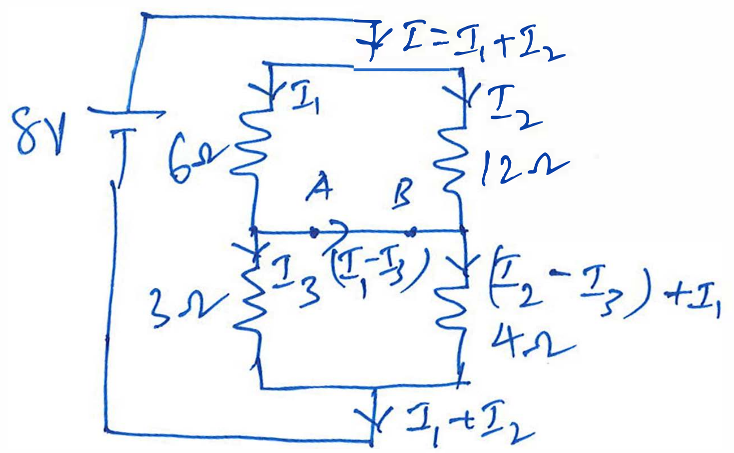
$I_L = \frac{0.67}{15} = 44.7\,mA$

$V_L = 0.447\,V$

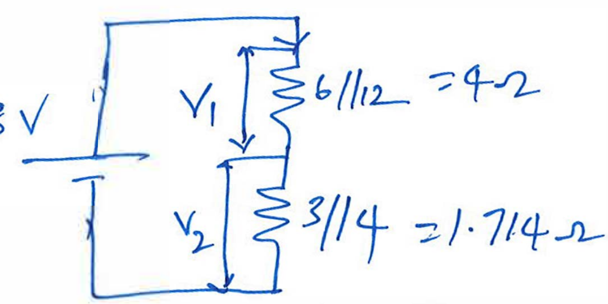
$P_L = V_L I_L = 20\,mW$

Norton Equivalent

$R_N = R_{TH} = 5\Omega$



=>



$I = 1.4\,A$ $V_1 = 5.6\,V$

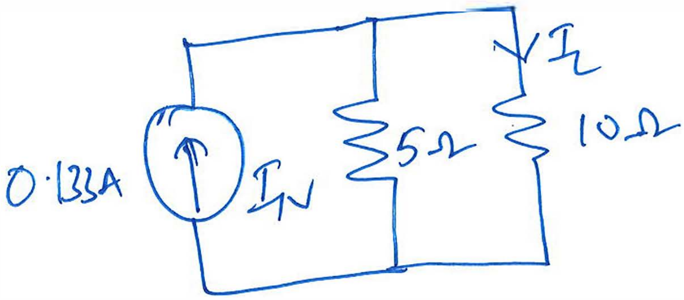
$V_2 = 2.4\,V$

$I_1 = 0.933\,A$ $I_2 = 0.467\,A$

$I_3 = \frac{2.4}{3\Omega} = 0.8\,A$

$I_{AB} = I_1 - I_3 = 0.933 - 0.8 = \underline{0.133\,A}$

$I_N = I_{AB} = 0.133\,A$

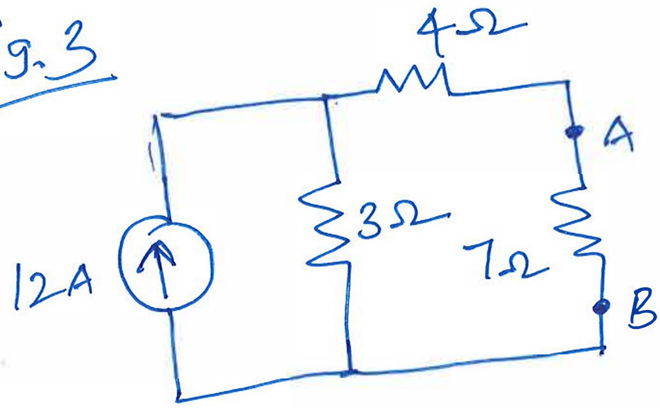


$I_L = 44.3\ mA$

$V_L = 0.443\ V$

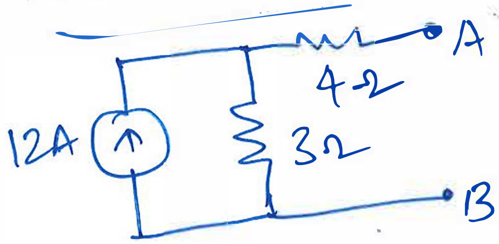
$P_L = V_L I_L \simeq 20\ mW$

Fig. 3

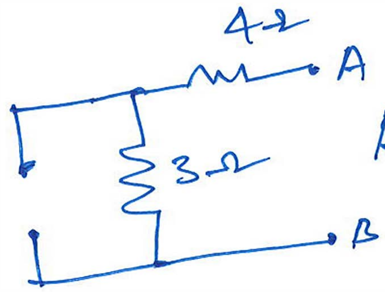


THEVININ'S Equivalent:

To find R_{TH}:



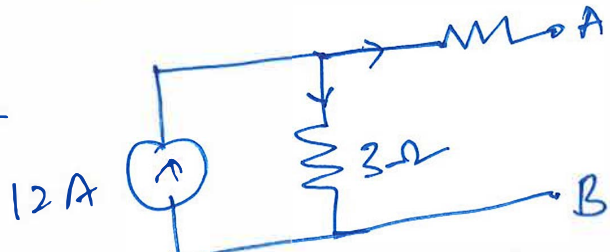
⇒



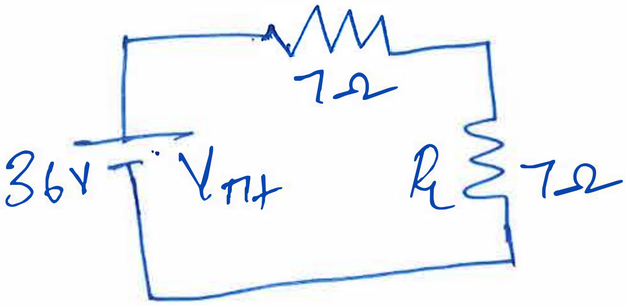
$R_{AB} = 7\Omega$

$R_{TH} = R_{AB} = 7\Omega$

To find V_{TH}



$V_{AB} = V_{3\Omega} = 12 \times 3 = 36\ V = V_{TH}$



$V_L = 18V$

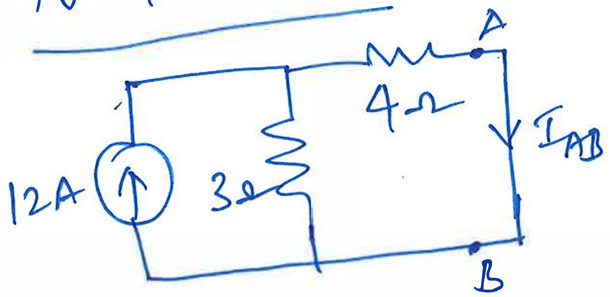
$I_L = 2.57 A$

$P_L = V_L I_L = \underline{46.286\ W}$

Norton's Equivalent

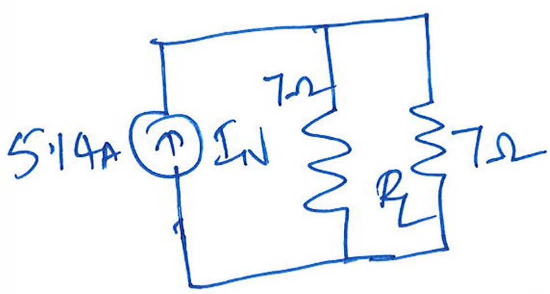
$R_N = R_{TH} = 7\Omega$

To find I_N:



$I_{4\Omega} = \frac{12 \times 3}{3+4} = 5.14A$

$I_N = I_{4\Omega} = \underline{5.14 A}$

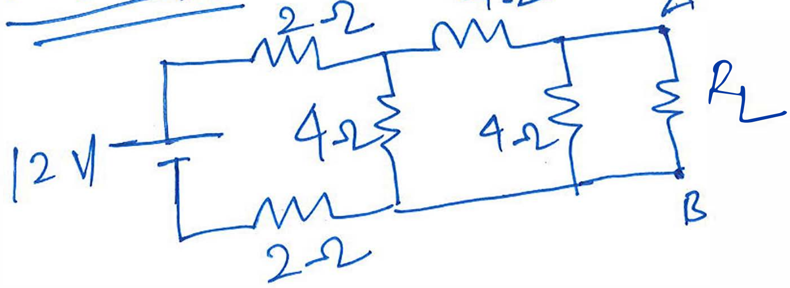


$I_L = \frac{5.14 \times 7}{7+7} = 2.57A$

$V_L = 2.57 \times 7 = 18 V$

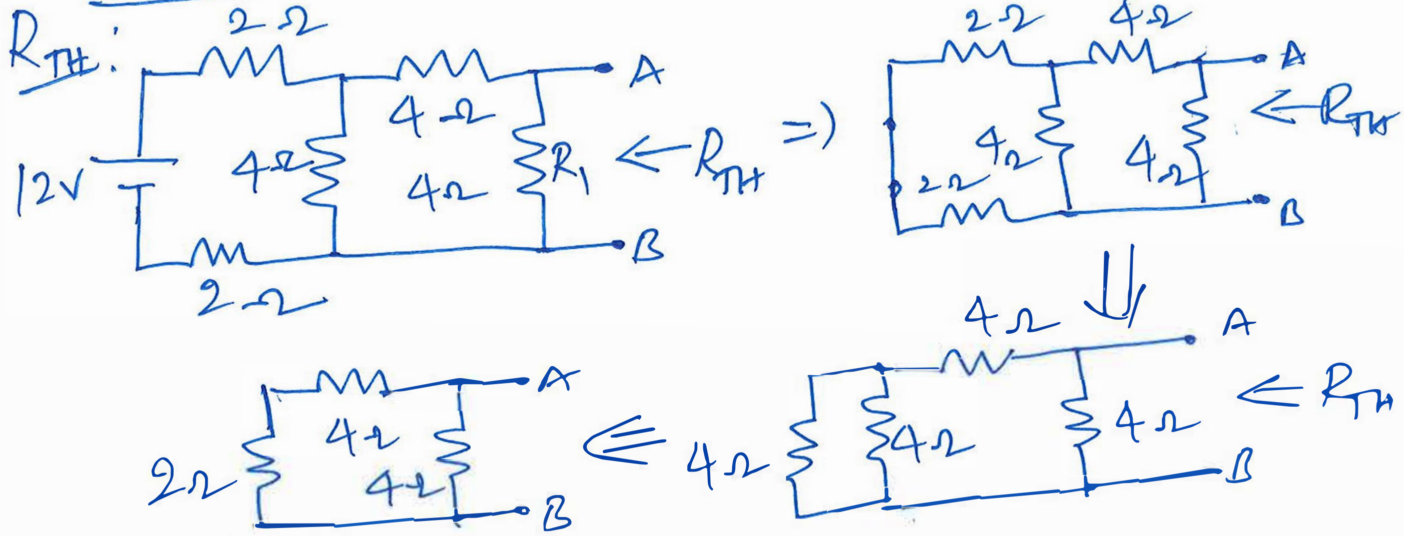
$P_L = V_L \cdot I_L = \underline{46.286\ W}$

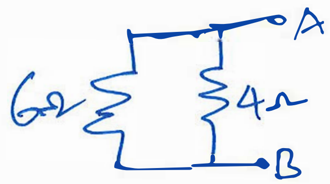
Fig. 4



THEVININ'S EQUIVALENT

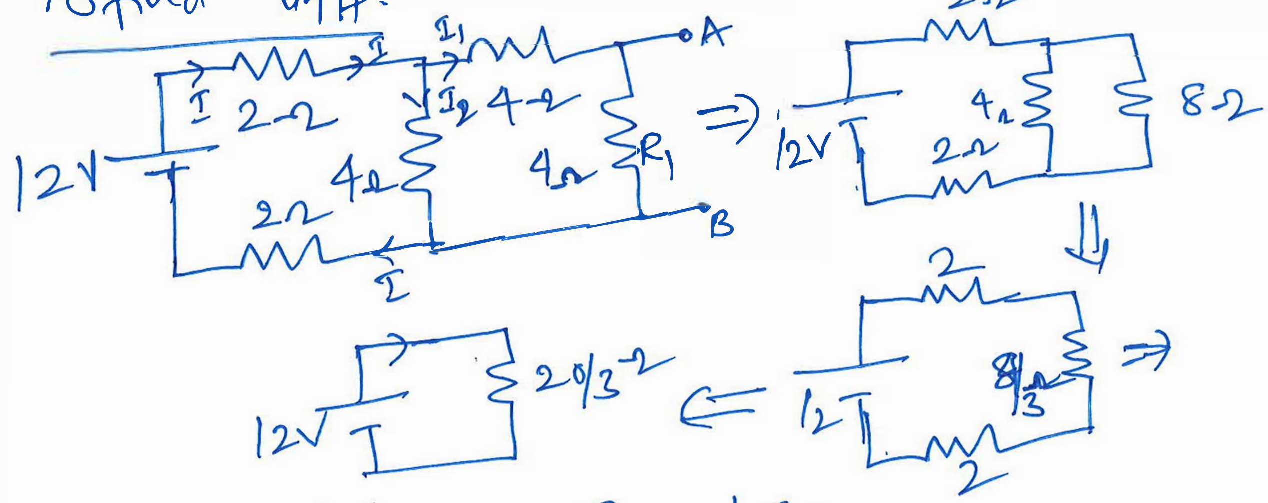
R_{TH}:





$R_{AB} = 2.4\Omega = \underline{R_{TH}}$

To find V_{TH}:

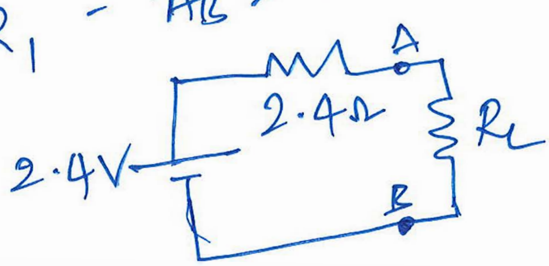


$I = 12/20/3 = \dfrac{9}{5} = 1.8A$

$I_2 = \dfrac{1.8 \times 4}{4+8} = 0.6A$

$V_{4\Omega} = 0.6 \times 4 = 2.4V$

$V_{R_1} = V_{AB} = 2.4V = V_{TH}$



for maximum power transfer

$\therefore R_L = R_{TH} = 2.4\,\Omega$

$$V_L = \frac{2.4V \;\; 2.4\,\Omega}{2.4 + 2.4} = 1.2\,V$$

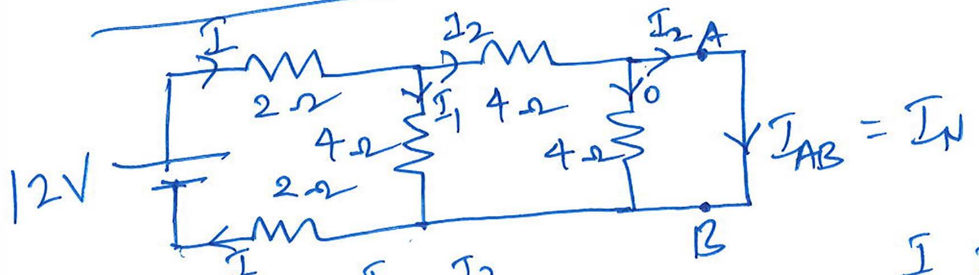
$$I_L = \frac{V_L}{R_L} = \frac{1.2}{2.4} = 0.5\,A$$

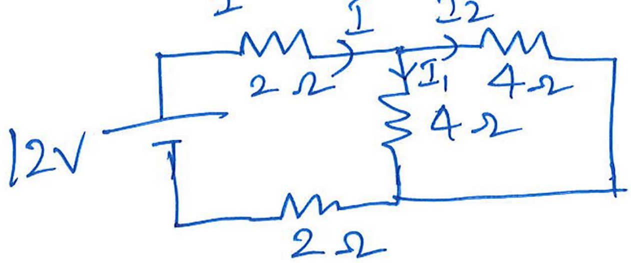
$$P_L = V_L I_L = \underline{0.6\,W}$$

Norton Equivalent

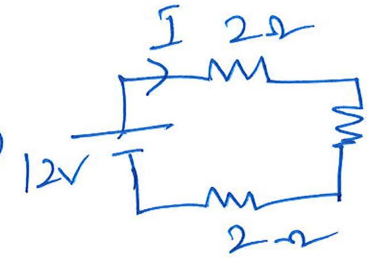
$R_N = R_{TH} = 2.4\,\Omega$

To find I_N:



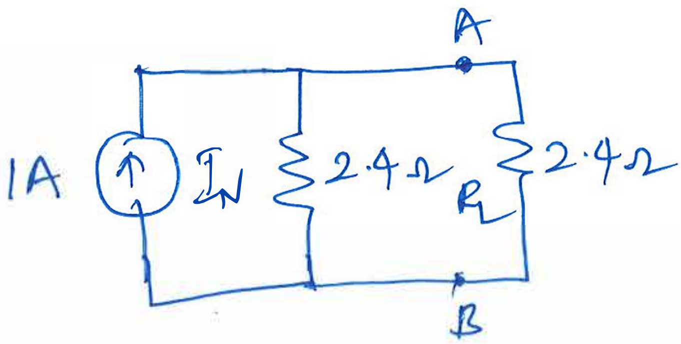


$\Rightarrow$



$I = \frac{12}{6} = 2A$

$$I_2 = \frac{2 \times 4}{4 + 4} = 1A \qquad I_2 = I_{AB} = I_N = 1A$$



for Maximum power transfer,

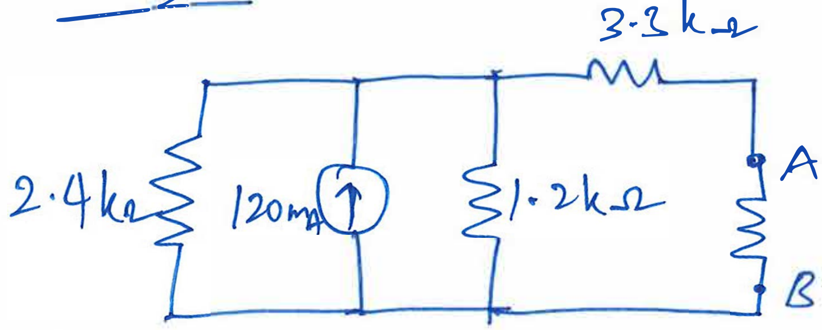
$R_L = R_N = 2.4\,\Omega$

$$I_L = \frac{1 \cdot 2.4}{2.4 + 2.4} = \underline{0.5\,A}$$

$$V_L = I_L R_L = 0.5 \times 2.4 = \underline{\underline{1.2\,V}}$$

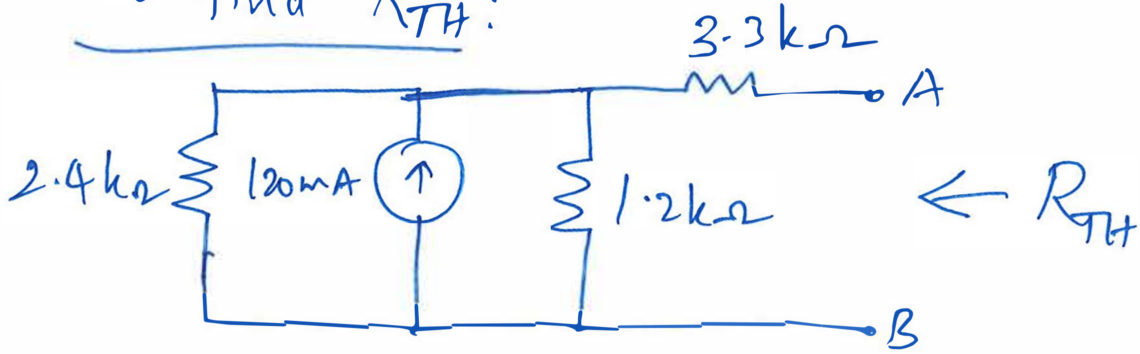
$$P_L = V_L I_L = \underline{\underline{0.6\,W}}$$

Fig. 5



THEVININ'S EQUIVALENT

To find R_{TH}:



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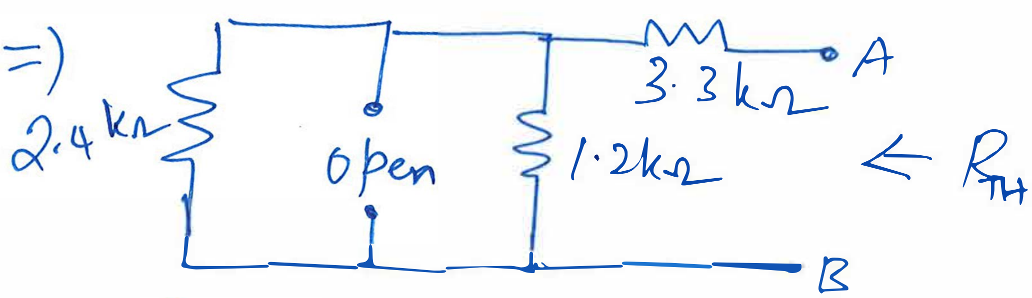
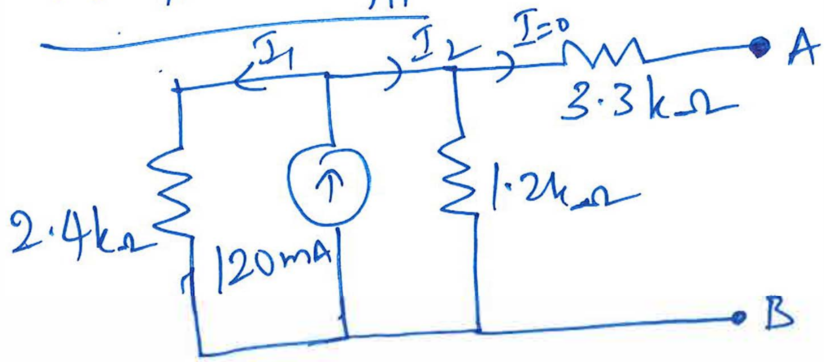


$$R_{AB} = 3.3\,k\Omega + (1.2k \,//\, 2.4k)\,\Omega =$$

$$= 3.3\,k\Omega + 0.8\,k\Omega = 4.1\,k\Omega$$

$$R_{TH} = R_{AB} = 4.1\,k\Omega$$

To find V_{TH}

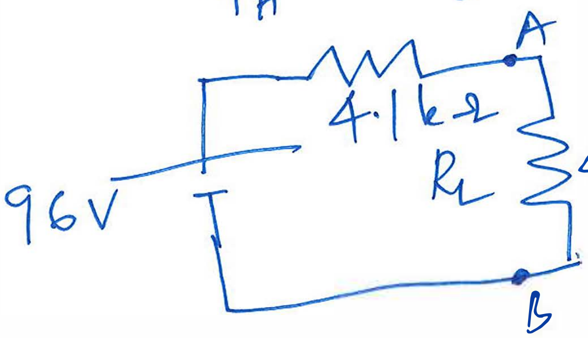


$V_{AB} = V_{TH}$

$$I_2 = \frac{120\,mA \times 2.4\,k\Omega}{(2.4k + 1.2k)\Omega} = 80\,mA$$

$$V_{AB} = V_{1.2k\Omega} = 80\,mA \times 1.2\,k\Omega = \underline{96\,V}$$

$$V_{TH} = V_{AB} = \underline{96V}$$



For maximum power, $R_L = R_{TH} = 4.1\,k\Omega$

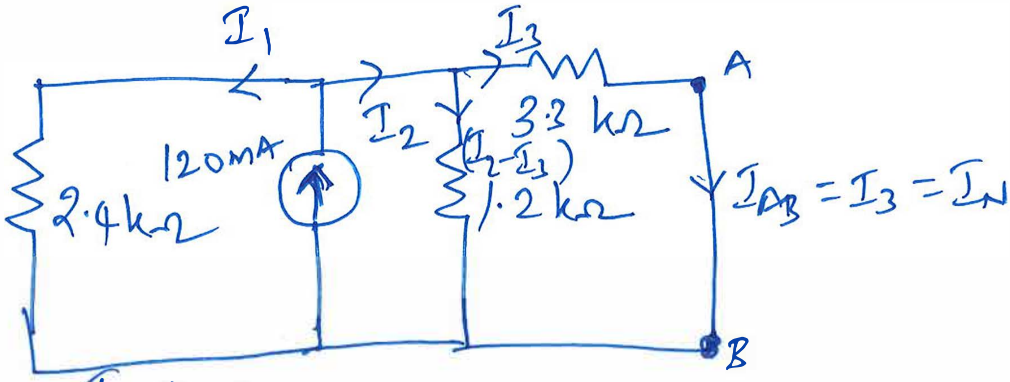
$$V_L = \frac{96 \times 4.1\,k\Omega}{4.1\,k\Omega + 4.1\,k\Omega} = 48\,V$$

$$I_L = \frac{V_L}{R_L} = 11.707\,mA$$

$$P_L = V_L I_L = \underline{0.56\,W}$$

NORTON'S EQUIVALENT

$$R_N = R_{TH} = 4.1\,k\Omega$$



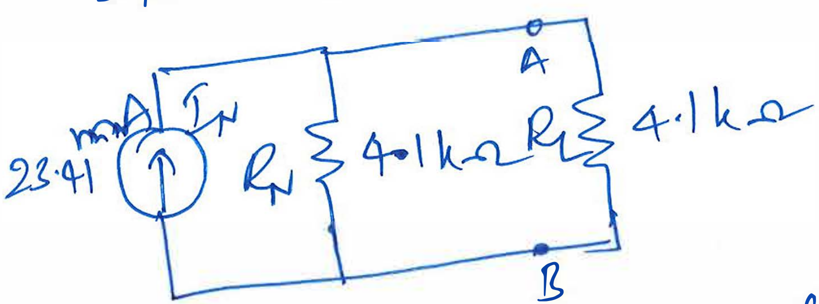
To find I_2:

$$(3.3k \parallel 1.2k) = 0.88\,k\Omega$$

$$I_2 = \frac{120\,mA \times 2.4\,k\Omega}{2.4\,k\Omega + 0.88\,k\Omega} = 87.8\,mA$$

$$I_3 = \frac{87.8 \times 1.2k}{1.2k + 3.3k} = 23.41\,mA = I_N$$

$$I_N = I_3 = I_{AB} = \underline{23.41\,mA}$$



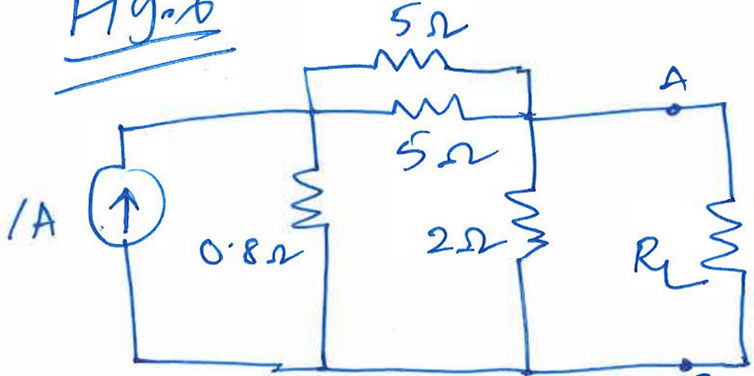
Maximum power is transferd when $R_L = R_N = 4.1\,k\Omega$

$$I_L = \frac{23.41\,mA \times 4.1\,k\Omega}{4.1\,k\Omega + 4.1\,k\Omega} = 11.707\,mA$$

$$V_L = I_L R_L = 48\,V$$

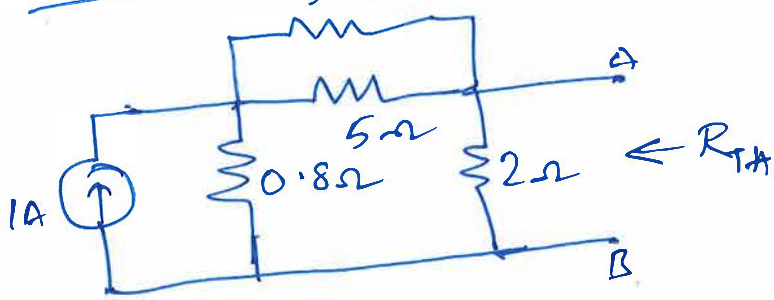
$$P_L = V_L I_L = 48 \times 11.707\,mA = \underline{0.56\,mW}$$

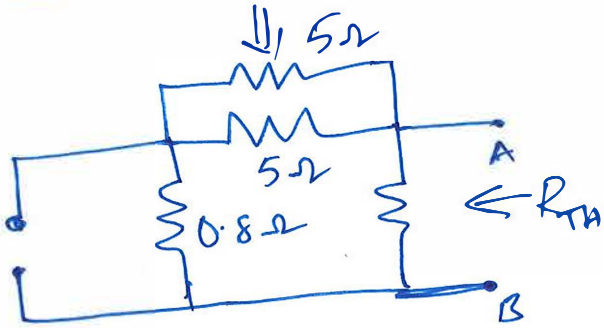
Fig. 6

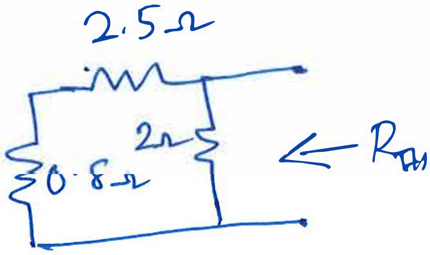


THEVININ'S EQUIVALENT:

R_{TH}:

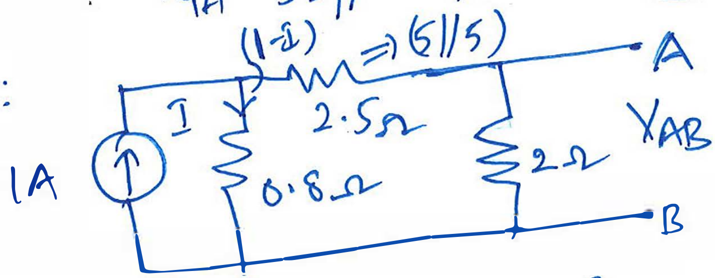


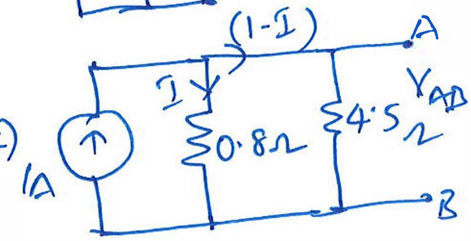




$R_{TH} = 3.3 \| 2 = 1.245\Omega$

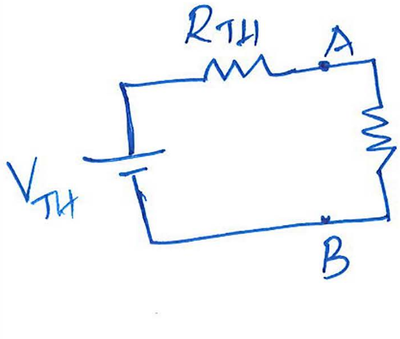
V_{TH}:





$$I = 1 \times \frac{0.8}{0.8 + 4.5} = 0.151\,A$$

$$V_{2\Omega} = 0.151 \times 2 = \underline{0.302V} = V_{AB} = V_{TH}$$



$R_{TH} = 1.245\Omega$ $\quad I_L = 0.121\,A$

$V_{TH} = 0.302\,V$ $\quad P_L = 18.31\,mW$ $(V_L \cdot I_L)$

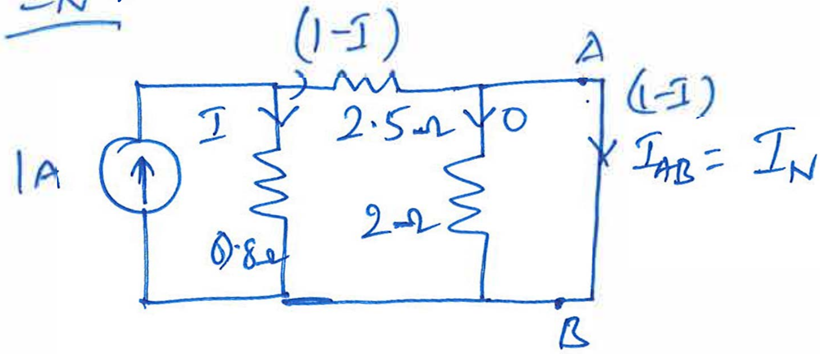
for maximum power transfer

$R_L = R_{TH} = 1.245\Omega$

Norton Equivalent

$R_N = R_{TH} = 1.245\,\Omega$

I_N:

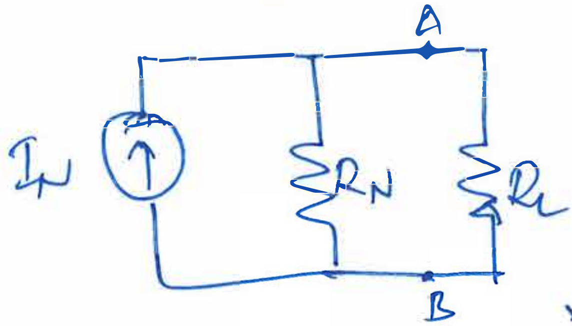


$$I_{AB} = 1 - \underbrace{\frac{2.5}{3.3} \times 1}_{} = 0.2424\,A$$

i) Current division between 0.8Ω and 2.5Ω

ii) No I through 2Ω

Norton Equivalent:



$I_N = 0.2424A$

$R_N = 1.245\,\Omega$

$R_L = R_N$ (for maximum power transfer)

$I_L = \dfrac{0.2424 \times 1.245}{1.245 + 1.245}$

$= \cancel{0.212A}\ 0.121A$

$V_L = I_L R_L = 0.151\,\cancel{A}$

$P_L = V_L I_L = \underline{18.3\,mW}$