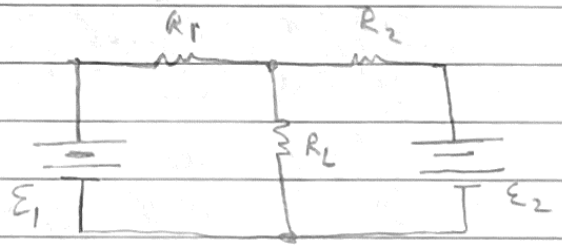
Experiment 4
Network Analysis II

The Thevenin and Norton Techniques

* kirchoff's laws and SPP are useful techniqeses for analyzing networks that cantain a few circuit element

* Complecated networks requires methods such as the equivalent circuit techniques of Thevenin and Norton

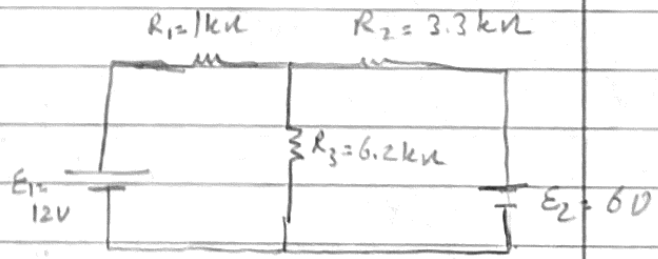
* Thevnin's theorem states that : any network of resistors and supplies having two out put terminals can be replaced by a series combinahon of a voltage source ($\mathcal{E}_{eq}$) and a resistor (R_{eq})



$R_1 = 1k\Omega$
$R_2 = 3.3k\Omega$
$R_3 = 6.2k\Omega$
$\mathcal{E}_1 = 12$ volt
$\mathcal{E}_2 = 6$ volt

* Thevenin :

(A) Finding T_{h3} ⇒ (So let $R_L = R_3$)



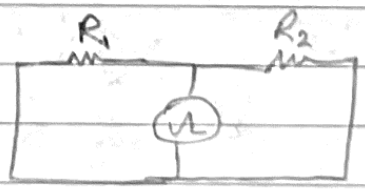
(1) Remve R_L (which is R_3 in our case A), kill both sources and Find R_{eq} (by conneching ohmmeter or multimeter on ohm's mode)

calculator

$$R_{eq} = R_1 \parallel R_2$$

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

$$R_{eq} = \frac{1 \times 3.3}{1 + 3.3}$$



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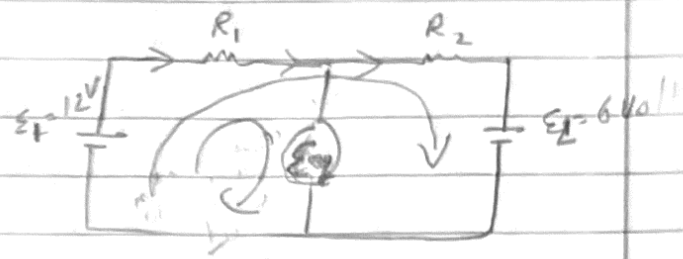
$R_{eq} = 0.767\ k\Omega$

(2) Return both sources ($\mathcal{E}_1, \mathcal{E}_2$) and Find $\mathcal{E}_{eq}$, I_{eq}
* by connecting voltmeter or multimeter for $\mathcal{E}_{eq}$
* by connecting Ameter or multimeter for I_{eq}

From the large loop



$$\mathcal{E}_1 - IR_1 - IR_2 - \mathcal{E}_2 = 0$$
$$\mathcal{E}_1 - \mathcal{E}_2 - I(R_1 + R_2) = 0$$

$$I = \frac{\mathcal{E}_1 - \mathcal{E}_2}{R_1 + R_2} = \frac{12 - 6}{(1 + 3.3)\,k\Omega} = 1.395\ mA$$

From the small loop

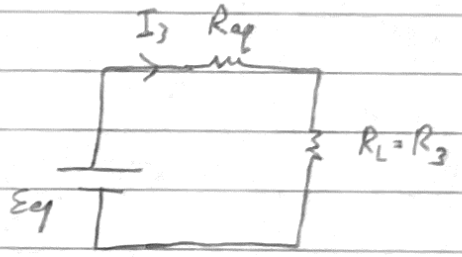
$$\mathcal{E}_1 - IR_1 - \mathcal{E}_{eq} = 0 \Rightarrow \mathcal{E}_{eq} = \mathcal{E}_1 - IR_1 = 12 - 1.395\,mA \times 1\,k\Omega = 10.605\ Volt$$

$$I_{eq} = \frac{\mathcal{E}_{eq}}{R_{eq}} = \frac{10.605}{0.767 \times 10^3} = 13.83\ mA$$

(3) construct Thevenin's circuit

$$I_{L_3} = \frac{\mathcal{E}_{eq}}{R_{eq} + R_3}$$

$$= \frac{10.605}{(0.767 + 6.2)\,k\Omega}$$



$$I_3 = 1.522\ mA \Rightarrow I_{L_3} = 1.522\ mA$$

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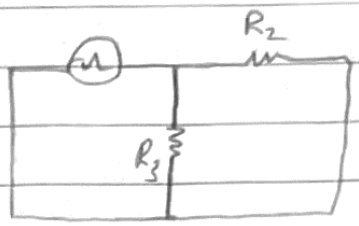
(B) Finding I_1 ⇒ (so let $R_L = R_1$)

(1) Remove R_L, kill both sources and Find R_{eq}

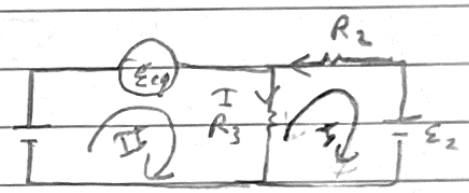


$$R_{eq} = R_2 \,||\, R_3 = \frac{R_2 R_3}{R_2 + R_3} = \frac{3.3 \times 6.2}{3.3 + 6.2}$$

عوضت بـ kΩ فالناتج بـ kΩ

$$\boxed{R_{eq} = 2.15\ k\Omega}$$

(2) Return both sources and Find $\mathcal{E}_{eq}$



I) $I R_3 + I R_1 - \mathcal{E}_2 = 0$

$I(R_3 + R_1) - \mathcal{E}_2 = 0$

$$I = \frac{\mathcal{E}_2}{R_3 + R_2} = \frac{6}{(6.2+3.3)k\Omega} = 0.63\ mA$$

II) $\mathcal{E}_1 - \mathcal{E}_{eq} - I R_3 = 0$

$\mathcal{E}_{eq} = \mathcal{E}_1 - I R_3$

$= 12 - 0.63 \times 6.2$

k × m تلغي

$$\boxed{\mathcal{E}_{eq} = 8.094\ Volt}$$

$$I_{eq} = \frac{\mathcal{E}_{eq}}{R_{eq}} = 3.76\ mA$$

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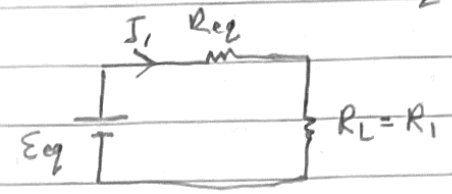
(3) construct Thevenin's circuit لـ هذا الدارة وصل المقاومة R_L و R_{eq} على التوالي مع مصدر الجهد $\mathcal{E}_{eq}$



$$I_1 = \frac{\mathcal{E}_{eq}}{R_{eq} + R_L}$$

$$I_1 = \frac{8.094}{(2.15 + 1)\,k\Omega}$$

$$\boxed{I_1 = 2.569\ mA} \Rightarrow I_{L_1} = 2.569\ mA$$

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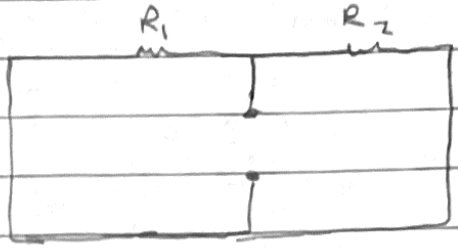
Norton's

Finding I_{L3} let $R_L = R_3$

① Remove $R_L \Rightarrow (R_3)$, killing sources and find R_{eq} by connecting to ohmmeter

$$\boxed{R_{eq} = R_1 \parallel R_3}$$

$$R_{eq} = \frac{R_1 R_3}{R_1 + R_3}$$

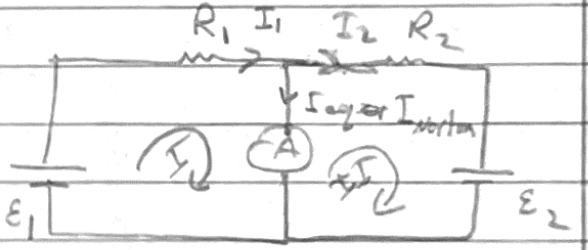


$\Rightarrow R_{eq} = 0.767\ k\Omega$

② Return both sources and calculate I_{eq} (by connecting Ammeter or multimeter) then find I_{eq} (I_{Norton})

$I_{eq} + I_2 = I_1$

$I_{eq} = I_1 + I_2$



small loop I

$\varepsilon_1 - I_1 R_1 = 0$

$I_1 = \frac{\varepsilon_1}{R_1} = \frac{12}{1k\Omega} = 12\ mA$

loop II

$-I_2 R_2 - \varepsilon_2 = 0$

$I_2 = -\frac{\varepsilon_2}{R_2} = \frac{-6}{3.3k\Omega} = -1.82\ mA$

$I_{eq} = I_1 + I_2 = 12\ mA - 1.82$

$= 13.82\ mA$

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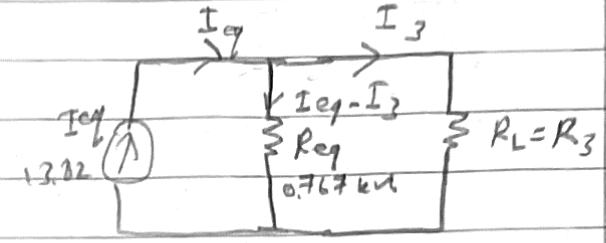
③ construct Norton circuit



$$I_3 R_3 = I_{eq} (R_3 \| R_{eq})$$

$$I_3 R_3 = I_{eq} \frac{R_3 R_{eq}}{R_3 + R_{eq}}$$

$$I_3 = \frac{I_{eq}}{R_3} \frac{R_3 R_{eq}}{R_3 + R_{eq}}$$

$$I_3 = \frac{I_{eq} R_{eq}}{R_3 + R_{eq}}$$

$$= \frac{13.82 \times 0.767}{6.2 + 0.767}$$

$$I_3 = 1.52 \text{ mA} \Rightarrow \boxed{I_{L_3} = 1.52 \text{ mA}}$$

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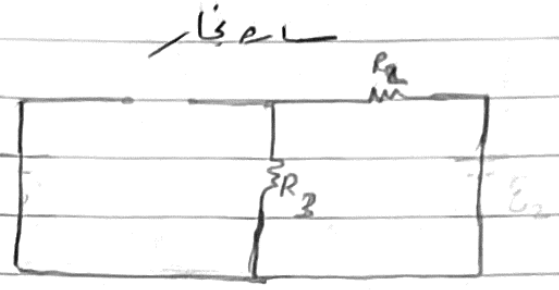
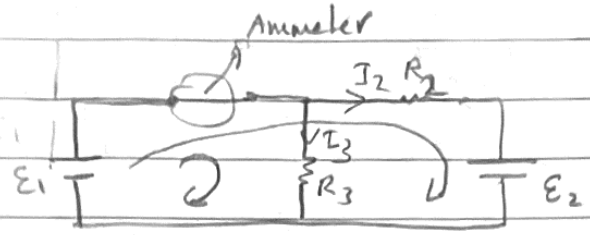
Norton

For $R_L = R_1$ Finding I_L



① Remove $R_L (R_1)$, killing sources and Find R_{eq}

$$R_{eq} = R_2 \| R_3 = \frac{R_2 R_3}{R_2 + R_3} \Rightarrow R_{eq} = 2.15\ k\Omega$$



② Return both Sources and Calculate I_{eq} (by connecting Ammeter or multimeter) then Find I_{eq} (I_{Norton})

$$I_{eq} = I_2 + I_3$$

From small Loop:

$$\mathcal{E}_1 - I_3 R_3 = 0$$

$$I_3 = \frac{\mathcal{E}_1}{R_3} = \frac{12}{6.2k\Omega} = 1.935\ mA$$

From the large loop:

$$\mathcal{E}_1 - I_2 R_2 - \mathcal{E}_2 = 0$$

$$I_2 R_2 = \mathcal{E}_1 - \mathcal{E}_2$$

$$I_2 = \frac{\mathcal{E}_1 - \mathcal{E}_2}{R_2} = \frac{12 - 6}{3.3k\Omega} = 1.82\ mA$$

$$\Rightarrow I_{eq} = I_3 + I_2 = 1.935 + 1.82 = 3.755\ mA$$

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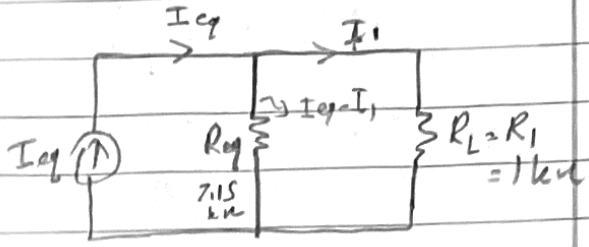
③ construct Norton circuit



$V_{Thvenin\,R_1} = V_{Thvenin}\,(R_1 \| R_{eq})$

$I_1 R_1 = I_{eq}\,(R_1 \| R_{eq})$

$I_1 R_1 = I_{eq}\,\dfrac{R_1 R_{eq}}{R_1 + R_{eq}}$

$I_1 = \dfrac{I_{eq}}{R_1}\,\dfrac{R_1 R_{eq}}{R_1 + R_{eq}}$

$I_1 = \dfrac{I_{eq}\,R_{eq}}{R_1 + R_{eq}}$

$= \dfrac{3.753 \times 2.15}{(1 + 2.15)\,k\Omega}$

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

$\boxed{I_1 = 2.56\ mA}$

or $I_{L_1} = 2.56\ mA$

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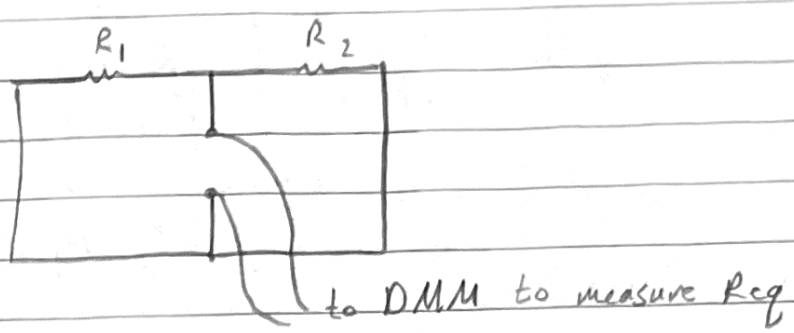
Thevinin

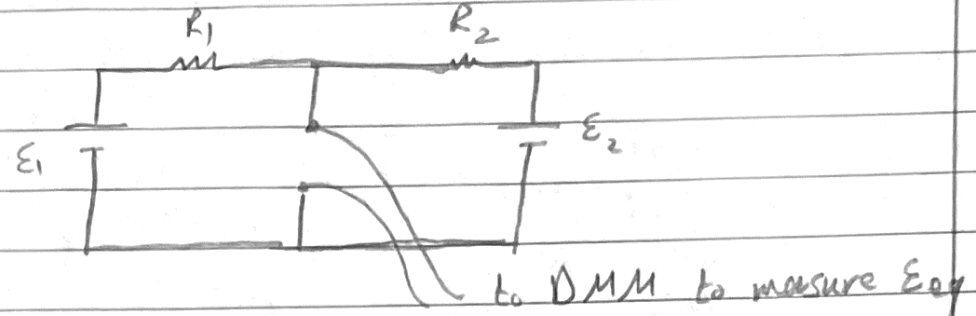
Step ①

قم بإزالة المصادر $\varepsilon_1, \varepsilon_2$ و وضع DMM مكان R_3 لقياس R_{eq}

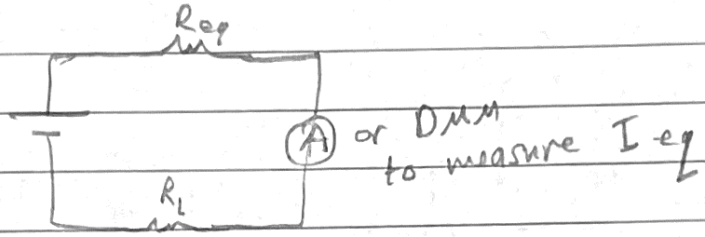


Step ②

ثم إزالة R_3 والبطارية ε_1 و ε_2 و وضع DMM مكان R_3 لقياس ε_{eq}



Step ③

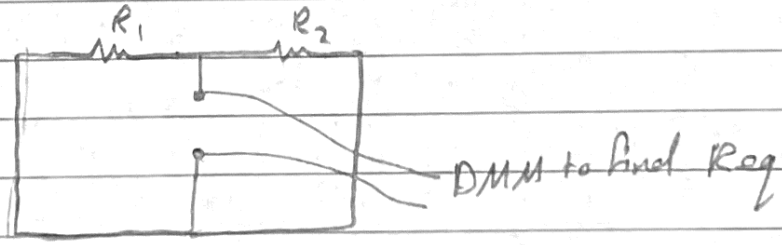


ثم توصل الدارة R_L ، R_{eq} مع ε_{eq} على التوالي وقياس I_{eq}

Norton

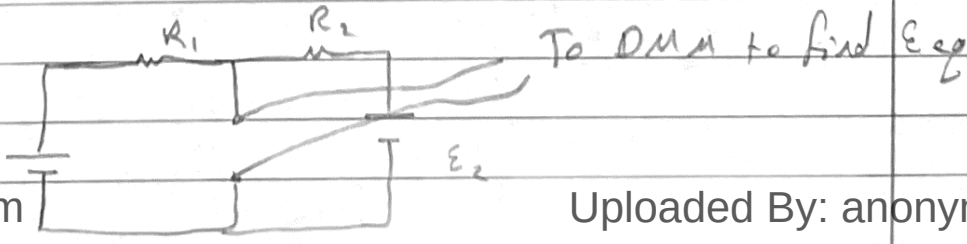
Step ①

ثم إزالة المصادر $\varepsilon_1, \varepsilon_2$ و وضع DMM مكان R_3



Step ②

ثم إعادة المصادر $\varepsilon_1, \varepsilon_2$ و DMM لقياس I_{eq}



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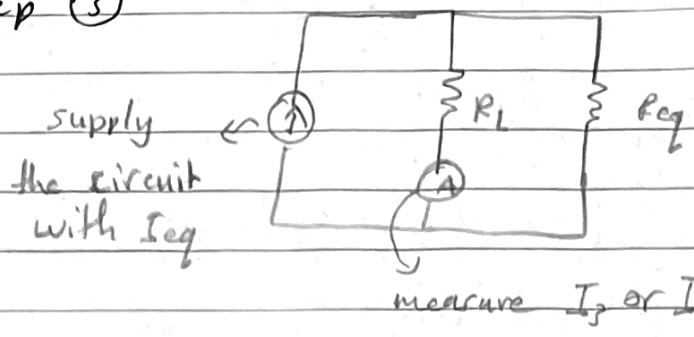
step (3)



measure I_2 or I_L using DMM or A

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