

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Experiment 3
Network Analysis 1

The superposition principle and kirchhoff's laws

- * Electric networks : circuits that include many elements such as resistors, voltage sources and current sources that are connected together in a rather complicated way.
- * Applying Ohm's law and simple parallel and series connection rules is of no practical help for the Electric networks
- * kirchhoff's laws and the superposition principle is used for our case

kirchhoff's laws

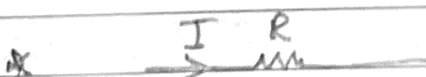
① Loop theorem : (conservation of energy)

The algebraic sum of the voltage drops and electromotive forces (emf's) in a closed electric circuit is always zero. In other words, the power generated by sources in a closed circuit is totally consumed by the circuit components

$$\sum_i V_i = 0$$

$$\sum_k \mathcal{E}_k = \sum_j I_j R_j$$

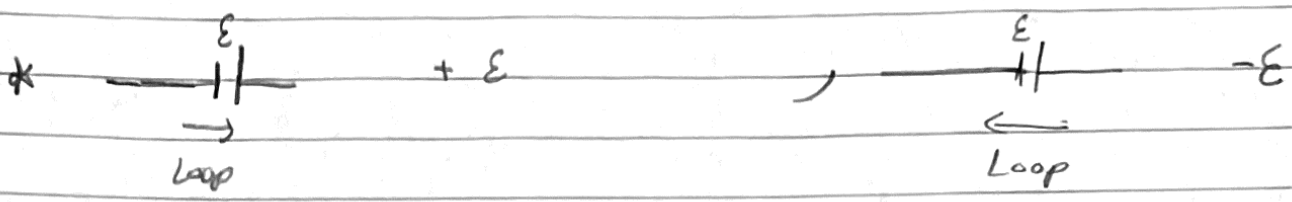
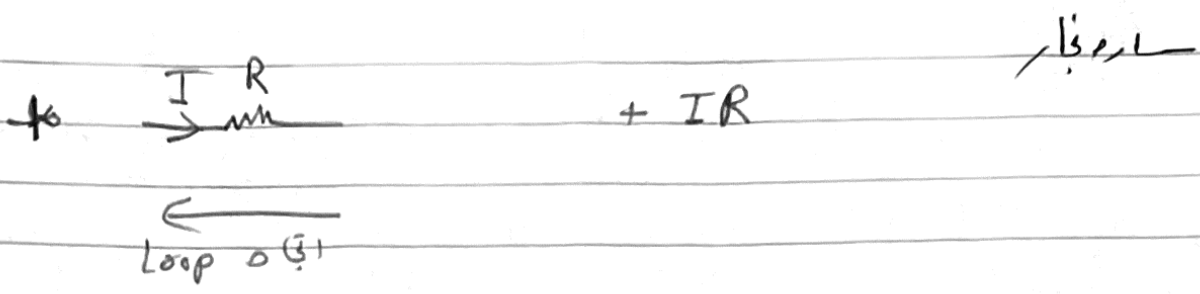
- * Voltage drops (IR) and emf's (E) are opposite signs
- * If any current is found to be negative, its assigned must be reversed
- * some rules



$$-IR$$

لا يزال

(2)

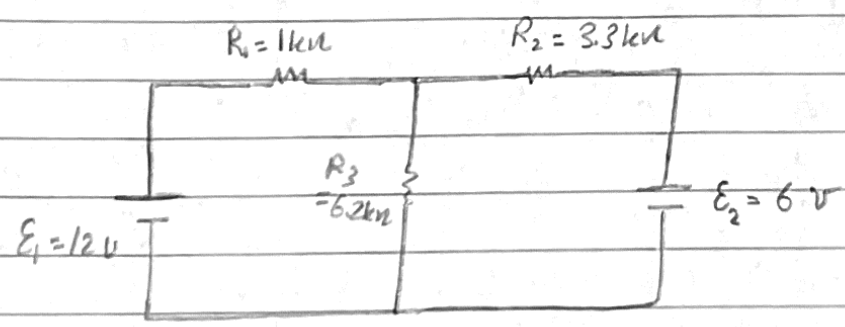


② Junction theorem : (conservation of charge)

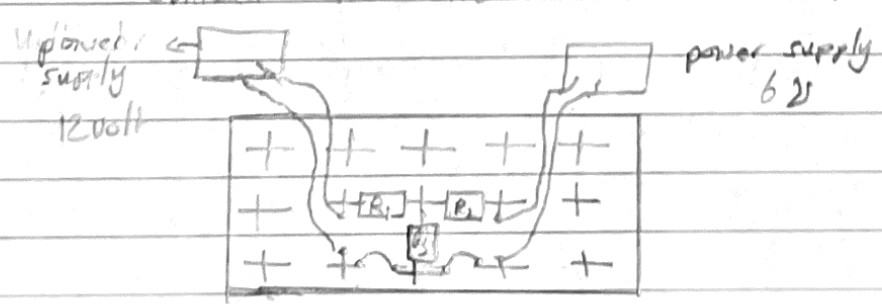
The algebraic sum of the currents passing through any circuit junction is always zero.

$$\sum_j I_j = 0$$

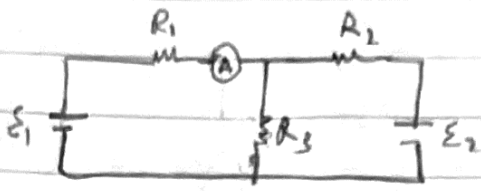
- the currents entering a junction have opposite signs to those leaving it



connect the circuit as the following

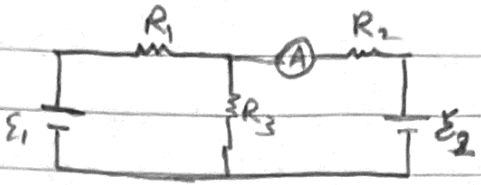


3

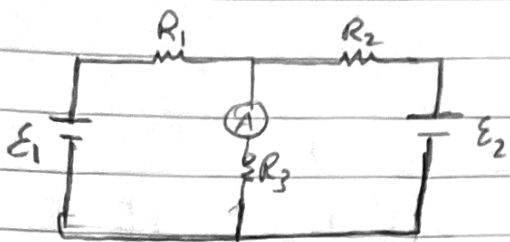


⇒ To measure I_1

• you put the digital multimeter in each branch to measure I



⇒ To measure I_2

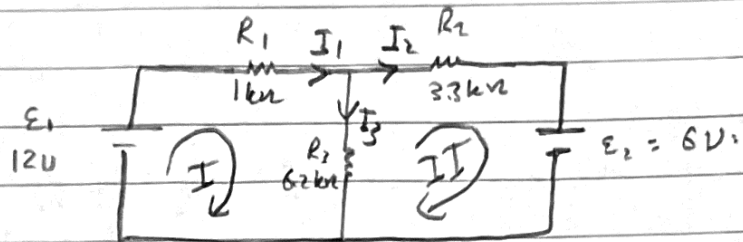


⇒ To measure I_3

$$\sum I_i = 0$$

$$I_1 = I_2 + I_3 \rightarrow \textcircled{1}$$

$$\sum V_i = 0$$



for $\textcircled{1}$: $E_1 - I_1 R_1 - I_3 R_3 = 0 \rightarrow \textcircled{2}$

for $\textcircled{2}$: $I_3 R_3 - I_2 R_2 - E_2 = 0$

$6.2 I_3 - 3.3 I_2 - 6 = 0 \rightarrow \textcircled{3}$

Sub $\textcircled{1}$ in $\textcircled{2}$

$E_1 - (I_2 + I_3) R_1 - I_3 R_3 = 0$

$12 - (I_2 + I_3) - 6.2 I_3 = 0$

$12 - I_2 - I_3 - 6.2 I_3 = 0$

$12 - I_2 - 7.2 I_3 = 0$

$-34.6 + 3.3 I_2 + 23.76 I_3 = 0 \rightarrow \textcircled{4}$

حل المعادلتين $\textcircled{3}$ و $\textcircled{4}$ نأخذ

لاحظ اننا عوضنا قيم R
و نأخذ (لا تنسى ان
تأخذ بعين الاعتبار الاشارة)

اضربه ب 3.3 طرفي المعادله

$$-45.6 + 29.96 I_3 = 0$$

المعادلة

(4)

$$45.6 = 29.96 I_3 \Rightarrow I_3 = \frac{45.6}{29.96} = 1.52$$

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

sub I_3 in eq 3

عوض I_3 في المعادلة 3

$$6.2 (1.52) - 3.3 I_2 - 6 = 0$$

$$9.424 - 6 - 3.3 I_2 = 0$$

$$3.424 = 3.3 I_2$$

$$\Rightarrow I_2 = \frac{3.424}{3.3} = 1.037 \approx 1.04 \text{ mA}$$

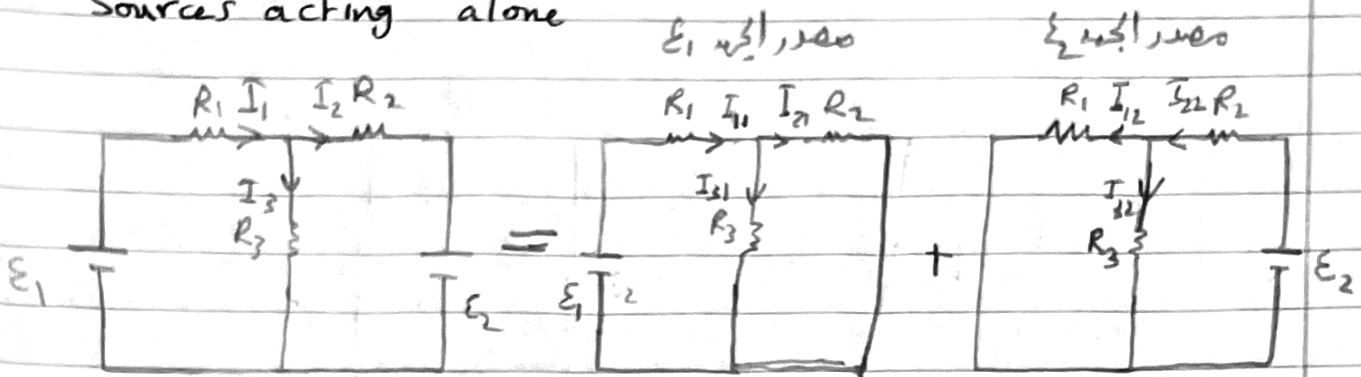
$$\boxed{I_2 = 1.04 \text{ mA}}$$

$$I_1 = I_2 + I_3 = 1.52 + 1.04 = 2.56 \text{ mA}$$

Line

The superposition principle (SPP)

The response ("a desired current or voltage" at any point in a linear circuit having more than one source can be obtained as the sum of the responses caused by each of the independent sources acting alone



(i)

(ii)

$I_1 = I_{11} + I_{12} \Rightarrow (a)$
 (Note: I_{11} is labeled as 'قيمة التيار في R_1 ' and I_{12} as 'قيمة التيار في R_1 ' in the original image)

$I_2 = I_{21} + I_{22} \Rightarrow (b)$

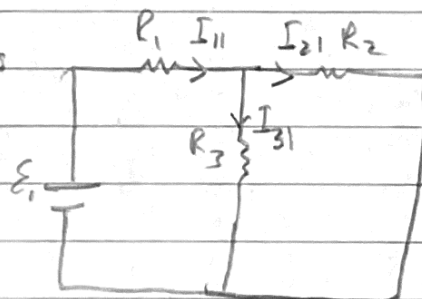
$I_3 = I_{31} + I_{32} \Rightarrow (c)$

* يجب الانتباه للاتجاهات
 * اذا كانت نفس الاتجاه ج
 * اذا كانت عكس الاتجاه طرح

* To find I_1 , we should find I_{11} from (i)
 * we should find I_{12} from (ii)
 and sub in eq (a)

(i) $R_2 \parallel R_3$ (parallel)
 R_1 with $(R_2 \parallel R_3)$ series

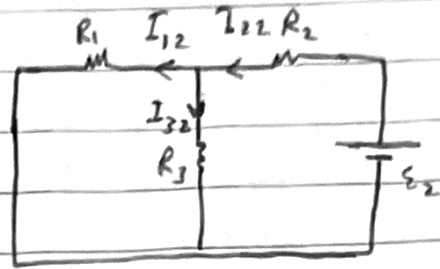
$I_{11} = \frac{E_1}{R_1 + (R_2 \parallel R_3)}$



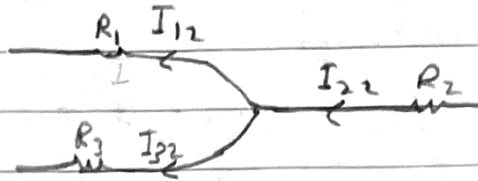
$I_{11} = \frac{E_1}{R_1 + \frac{R_2 R_3}{R_2 + R_3}} = \frac{12}{1 + \frac{3.3 \times 6.2}{3.3 + 6.2}} = 3.8 \text{ mA} \rightarrow$

(6)

ارادنا
 (ii) $R_1 \parallel R_3$
 $R_2, (R_1 \parallel R_3)$ series



لأن I_{12} اصغت فرع في دائرة وليست التيار الكلي فننقده على فكره تبادلي الجهد



$$I_{22} = \frac{\epsilon_2}{R_2 + (R_1 \parallel R_3)} = \frac{\epsilon_2}{R_2 + \left(\frac{R_1 R_3}{R_1 + R_3} \right)}$$

$$I_{22} = \frac{6}{3.3 + \left(\frac{1 \times 6.2}{1 + 6.2} \right)} = 1.44 \text{ mA}$$

$$V_{\text{through } R_1} = V_{\text{through } R_3} = V_{\text{through } (R_1 \parallel R_3)}$$

$$I_{12} R_1 = I_{32} R_3 = I_{22} (R_1 \parallel R_3)$$

$$\Rightarrow I_{12} R_1 = I_{22} (R_1 \parallel R_3)$$

$$I_{12} R_1 = I_{22} \frac{R_1 R_3}{R_1 + R_3}$$

$$I_{12} = I_{22} \frac{R_1 R_3}{R_1 + R_3} \frac{1}{R_1} = I_{22} \frac{R_3}{R_1 + R_3}$$

$$I_{12} = 1.44 \left(\frac{1 \times 6.2}{1 + 6.2} \right) \frac{1}{1}$$

$$I_{12} = 1.24 \text{ mA} \quad (\leftarrow)$$

(7)

from eq (a)

$$I_1 = I_{11} + I_{12}$$

مع مراعاة الاتجاهات

$$= 3.8 - 1.24$$

لانهم على اتجاهين

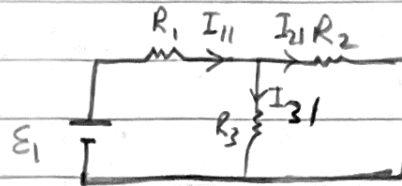
$$= 2.56 \text{ mA } (-)$$

الايجابيات الى اليمين

* To Find I_3

$$(i) I_{11} = \frac{\epsilon_1}{R_1 + R_2 \parallel R_3} = 3.8 \text{ mA}$$

مسئله قبل



$$V_{\text{through } R_2} = V_{\text{through } R_3} = V_{\text{through } (R_2 \parallel R_3)}$$

تاخذ الطرفين اللذين يفيدان في الاستدلال

$$V_{\text{through } R_3} = V_{\text{through } (R_2 \parallel R_3)}$$

$$I_{31} R_3 = I_{11} (R_2 \parallel R_3)$$

$$I_{31} R_3 = I_{11} \frac{R_2 R_3}{R_2 + R_3}$$

$$I_{31} = I_{11} \frac{R_2 R_3}{R_2 + R_3} \frac{1}{R_3}$$

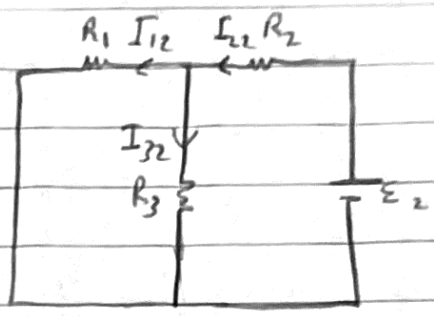
$$I_{31} = 3.8 \times \frac{3.3 \times 6.2}{3.3 + 6.2} \times \frac{1}{6.2}$$

$$I_{31} = 3.8 \times 2.15 \times \frac{1}{6.2}$$

$$I_{31} = 1.32 \text{ mA } \downarrow$$

(ii) $I_{22} = \frac{\epsilon_2}{R_2 + (R_1 \parallel R_3)} = \frac{\epsilon_2}{R_2 + \frac{R_1 R_3}{R_1 + R_3}}$

$I_{22} = 1.44 \text{ mA}$
 = 6.2 जो प्रतिमा



$V_{\text{through } R_1} = V_{\text{through } R_3} = V_{\text{through } (R_1 \parallel R_3)}$

$\Rightarrow V_{\text{through } R_3} = V_{\text{through } (R_1 \parallel R_3)}$

$I_{32} R_3 = I_{22} (R_1 \parallel R_3)$

$I_{32} R_3 = I_{22} \frac{R_1 R_3}{R_1 + R_3}$

$I_{32} = I_{22} \frac{R_1 R_3}{R_1 R_3} \frac{1}{R_3}$

$I_{32} = 1.44 \times \frac{1 \times 6.2}{1 + 6.2} \times \frac{1}{6.2}$

$I_{32} = 0.2 \text{ mA} \downarrow$

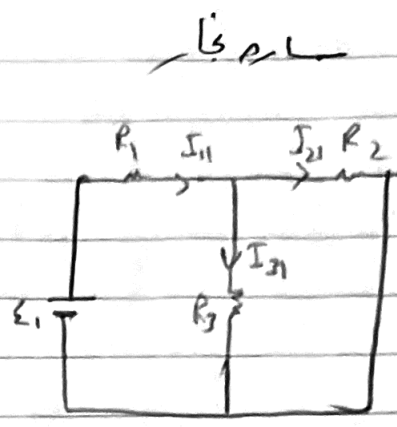
Sub I_{31}, I_{32} in eq c

$I_3 = I_{31} + I_{32}$
 $= 1.32 + 0.2$
 $= 1.52 \text{ mA} \downarrow$

जो 0.68 प्रतिमा

To find I_2 ($I_2 = I_{21} + I_{22}$)

(i) $I_{11} = \frac{\epsilon_1}{R_1 + R_2 \parallel R_3} = 3.8 \text{ mA}$



$V_{\text{through } R_2} = V_{\text{through } R_2 \parallel R_3}$

$I_{21} R_2 = I_{11} \frac{R_2 R_3}{R_2 + R_3}$

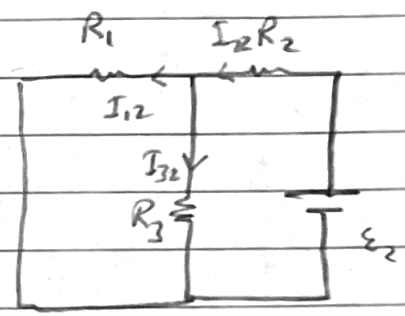
$I_{21} = I_{11} \frac{R_2 R_3}{R_2 R_3} \cdot \frac{1}{R_2}$

$= 3.8 \times \frac{3.3 \times 6.2}{3.3 + 6.2} \times \frac{1}{3.3}$

$I_{21} = 2.48 \text{ mA} \rightarrow$

(ii) $I_{22} = \frac{\epsilon_2}{R_2 + R_1 \parallel R_3}$

$= \frac{\epsilon_2}{R_2 + \frac{R_1 R_3}{R_1 + R_3}}$



$I_{22} = 1.44 \text{ mA} \rightarrow$

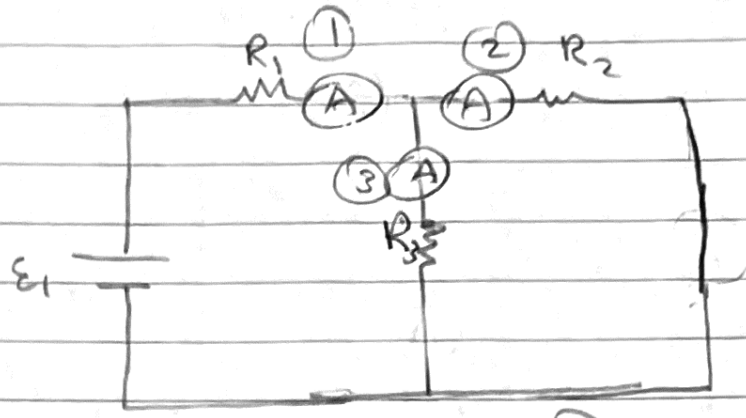
sub in eq (6)

$I_2 = I_{21} + I_{22}$
 $= 2.48 + 1.44$
 $= 1.04 \text{ mA}$

answer

① Taking off ϵ_2

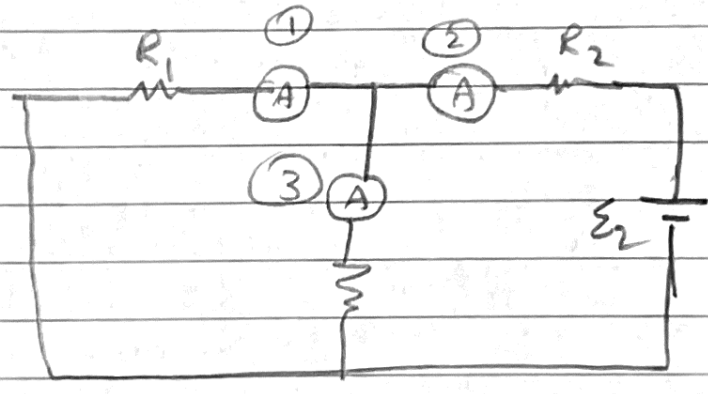
بالمنبر نزل ϵ_2



① I_{11} ② I_{21} ③ I_{31}

صحة وضع الأميتر عند كل فرع

② Taking off ϵ_1



① I_{12} ② I_{22} ③ I_{32}

صحة وضع الأميتر عند كل فرع

تم جمع التيار الذي حصلته عليه في مرحلتي 1 و 2
للوصول على I_1, I_2, I_3 ϵ_1 ϵ_2