اسس كهرباء

قسم هندسة تقنيات التبريد والتكييف

المرحلة الاولى

المحاضرة الثانية

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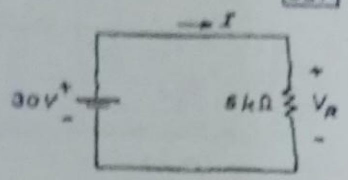
Example: In the circuit shown, calculate the current I, the conductance G, and the power p



Solution:

$V_R = V$

- the current $\quad I = \frac{V_R}{R} = \frac{30}{5 \times 10^{3}} = 6 \times 10^{-3} = \underline{6\ mA}$

- the conductance $\quad G = \frac{1}{R} = \frac{1}{5 \times 10^{3}} = 0.2 \times 10^{-3} = 0.2\ mS$

- the power $\quad P = V_R I = 30(6 \times 10^{-3}) = \underline{180\ mW}$

or

$P = I^2 R = (6 \times 10^{-3})^2 (5 \times 10^{3}) = \underline{180\ mW}$

or

$P = V_R^2 G = (30)^2 (0.2 \times 10^{-3}) = \underline{180\ mW}$

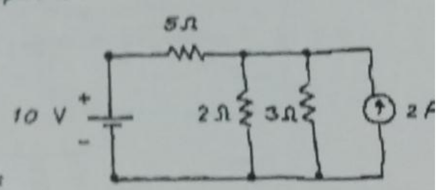
1.2.2 Nodes, branches and loops

* A branch represents a single element in the electric circuit, such as a voltage source or a resistor etc...

* A node represents the point of connection between two or more branches.

* A loop is any closed path in a circuit.

Example: For the circuit shown, determine the number of branches, nodes and the independent loops.



Solution

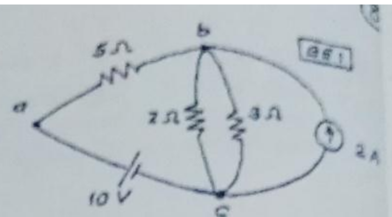
Since there are 5 elements

$\Rightarrow$ Number of branches $= \underline{5}$ $\quad$ 10V, 5Ω, 2Ω, 3Ω, and 2

Number of nodes $= \underline{3}$ (as shown in the figure).

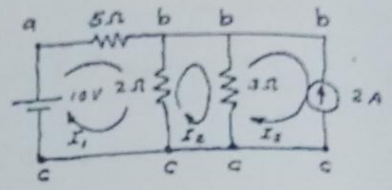
ثلاثة

نسخة من بنائي



➡ There are 3 nodes : a , b and c

* The number of the independent loops = 3



➡ loop 1 or loop abc : contains (10V, 5Ω, 2Ω)

➡ loop 2 or loop bcb : contains (2Ω, 3Ω)

& ➡ loop 3 or loop bcb : contains (3Ω, 2A)

Notes : There are more than 3 (dependent) loops in this example, we had only calculated the INDEPENDENT loops which are only 3.

IN GENERAL; Any circuit with b branches, n nodes and ℓ independent loops, the following fundamental theorem of network topology

$$\boxed{b = \ell + n - 1}$$

* Two or more elements are in **SERIES** if they are cascaded sequentially and consequently carry the SAME current.

* Two or more elements are in PARALLEL if they are connected to the same two nodes and have consequently the same VOLTAGE across them.

1.2.3 Kirchoff's Laws (1847) :

قانون كيرشوف للتيار * Kirchoff's current law (KCL); states that the algebraic sum of all current entering a node is zero or : The sum of currents entering a node is equal to the sum of curents leaving that node

$$\sum_{n=1}^{N} I_n = 0$$

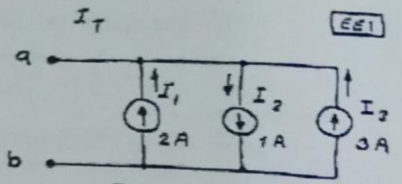
or

$$\boxed{\sum_{m=1}^{M} I_{mi} = \sum_{n=1}^{N} I_{no}}$$

where I_{mi} are the currents entering the node and I_{no} are the currents leaving the node.

Example

: For the network shown, calculate the total current I_T



Current Sources in Parallel

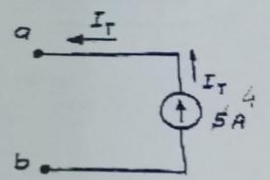
Solution

According to KCL;

$$I_T = I_1 - I_2 + I_3$$
$$= 2 - 1 + 3 = \underline{\underline{5\ A}}$$

4

$\therefore$ The equivalent circuit for the network can be as shown $\Rightarrow$



* **Kirchoff's Voltage Law (KVL)**; states that the algebraic sum of all voltages around a closed path (or loop) is zero.

قانون كرشوف للـ

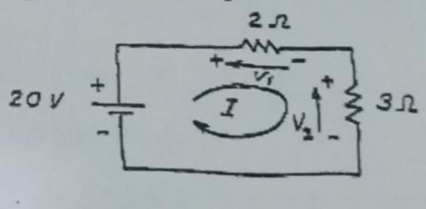
$\therefore$ Mathematically KVL states that:

$$\boxed{\sum_{m=1}^{M} V_m = 0}$$

where M is the number of voltages in the loop (or the number of branches in the loop), and V_m is the $\underline{m\text{th}}$ voltage.

Example

: For the circuit shown, find the voltages V_1 and V_2



Solution:

$$V_1 = 2I$$
$$V_2 = 3I$$

From KVL:

$$\sum V = 0 \Rightarrow 20 - V_1 - V_2 = 0 \Rightarrow 20 = 3I + 2I$$

$$\Rightarrow 5I = 20 \Rightarrow I = 4\ A$$

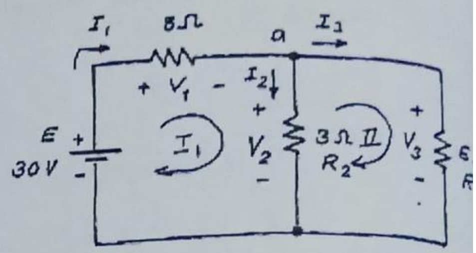
$$\therefore V_1 = 2I = \underline{\underline{8V}} \quad \text{and} \quad V_2 = 3I = \underline{\underline{12V}}$$

Tutorial Sheet № 1

Basic Concepts & Basic Laws

TS1

Example Using Kirchoff's laws, find the currents and voltages in the circuit shown.



ملاحظة : المطلوب في المثال ايجاد كل من :
I_1 , I_2 , I_3 , V_1 , V_2 & V_3
باستخدام قانون كيرشوف

Solution :

* Using Ohm's law:

$$V_1 = I_1 R_1 = 8 I_1$$
$$V_2 = I_2 R_2 = 3 I_2$$
$$V_3 = I_3 R_3 = 6 I_3$$

* Applying KCL at node $\underline{\underline{a}}$:

$$I_1 = I_2 + I_3 \Rightarrow \boxed{I_1 - I_2 - I_3}$$

Eq(1)

* Applying KVL to loop 1 ;

$$E - V_1 - V_2 = 0 \Rightarrow 30 - V_1 - V_2$$

$$\Rightarrow 30 - 8I_1 - 3I_2 = 0$$

$$\therefore \boxed{I_1 = \frac{30 - 3I_2}{8}} \quad Eq(2)$$

* Applying KVL to loop 2 ;

$$V_2 - V_3 = 0 \Rightarrow V_2 = V_3$$

لتوازي R_2 & R_3

$$\therefore 6I_3 = 3I_2$$

$$\boxed{\therefore I_3 = \frac{I_2}{2}} \quad Eq(3)$$

$\Rightarrow$ From Eq(1) , Eq(2) & Eq(3)

$$\frac{30 - 3I_2}{8} - I_2 - \frac{I_2}{2} = 0 \Rightarrow \underline{\underline{I_2 = 2\ A}}$$

$$\text{and } I_1 = \frac{30 - 3I_2}{8} = \frac{30 - 3(2)}{8} = \underline{\underline{3\ A}}$$

$$I_3 = \frac{I_2}{2} = \frac{2}{2} = 1\ A$$

$\Rightarrow \because V_1 = 8 I_1 \quad \Rightarrow \quad \therefore V_1 = 8(3) = 24\ V$ $\boxed{TS1}$

Similarly $\quad V_2 = 3 I_2 = 3(2) = 6\ V$

and $\quad V_3 = 6 I_3 = 6(1) = 6\ V$

للتأكد من صحة الحل :

$$I_1 = I_2 + I_3$$
$$3 = 2 + 1 \Rightarrow 3 = \underline{\underline{3}}$$

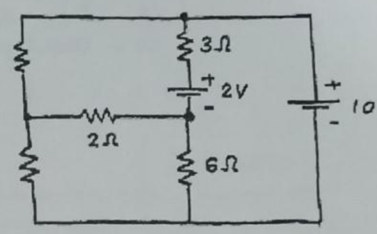
كذلك فإن تطبيق قانون كرشوف للفولتية على المسار المغلق رقم 1 ينتج ما يأتي :

$$\because E = V_1 + V_2$$
$$\therefore 30 = 24 + 6$$
$$\therefore 30 = 30$$

∴ الحل صحيح

Example

: Determine the number of branches, nodes and independent loops in the circuit shown.



Solution

:

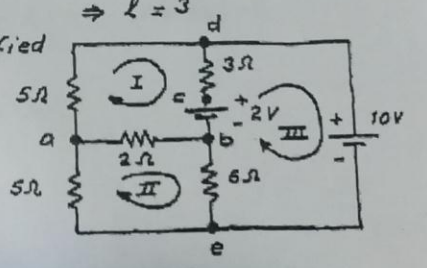
* There are $\underline{\underline{7}}$ element $\Rightarrow$ no. of branches $= \underline{\underline{7}}$
$\Rightarrow \underline{b = 7}$

,b,c,d,e $\Leftarrow$ * There are 5 nodes as shown in the figure :
$\Rightarrow n = 5$

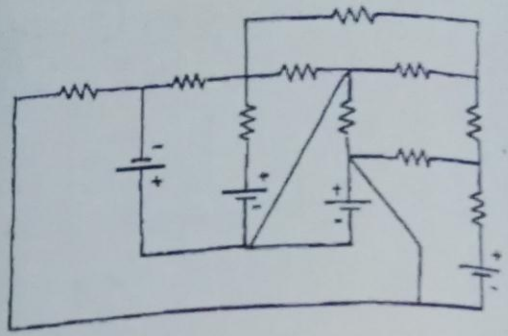
I, II, III $\Leftarrow$ * There are 3 independent loops :
$\Rightarrow \ell = 3$

$\therefore b = \ell + n - 1$ is satisfied

since $\quad 7 = 3 + 5 - 1$
$\Rightarrow 7 = 7$



Practice Problem: Identify all nodes, branches and independent loops in the circuit shown in the figure.



Answer:

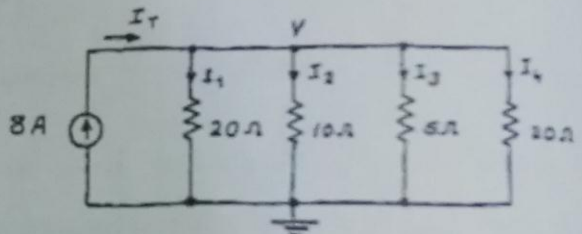
no. of nodes = 8 $\quad n = 8$
no. of branches = 14 $\quad b = 14$
no. of independent loops = 7 $\quad l = 7$

Check. Does this satisfy the fundamental theorem of network topology?

$$b = l + n - 1 = 7 + 8 - 1 = 14 \quad \text{YES}$$

Example: Determine all currents and voltages in the circuit of the figure shown.

$l = 4$
$b = 5$
$b = l + n - 1$
$5 = 4 + n - 1$
$5 = 3 + n \quad \therefore n = 5 - 3 = 2$



Solution: KCL ⇒

$$I_T = I_1 + I_2 + I_3 + I_4 \Rightarrow 8 = I_1 + I_2 + I_3 + I_4$$

Ohm's law

$$V = 20 I_1 \Rightarrow I_1 = V/20$$
$$= 10 I_2 \qquad I_2 = V/10$$
$$= 5 I_3 \qquad I_3 = V/5$$
$$= 20 I_4 \qquad I_4 = V/20$$

Substituting in the current equation;

TS1

$$\Rightarrow \quad 8 = \frac{V}{20} + \frac{V}{10} + \frac{V}{5} + \frac{V}{20}$$

$$\therefore \quad 160 = V + 2V + 4V + V$$

$$160 = 8V$$

$$\therefore \quad \underline{V = 20 \text{ Volts}}$$

$$\therefore \quad I_1 = \frac{V}{20} = \frac{20}{20} = 1\ A$$

$$I_2 = \frac{V}{10} = \frac{20}{10} = 2\ A$$

$$I_3 = \frac{V}{5} = \frac{20}{5} = 4A$$

$$I_4 = \frac{V}{20} = \frac{20}{20} = 1\ A$$

Check

$$I_T = I_1 + I_2 + I_3 + I_4$$

$$8 = 1 + 2 + 4 + 1$$

$$8 = 8 \checkmark$$