Al-Mustaqbal University
College Of Engineering Technology
Department Of Cyber Security Techniques Engineering
Class: 1st
Subject: fundamental of electrical engineering
Lecturer: Dr. Rami Qays Malik
1st term – Lecture: 3- Series & Parallel Circuits

الكلية التقنية الهندسية

قسم هندسة تقنيات الامن السيبراني

Lecture: 3- Series & Parallel Circuits

Email: rami.qays@uomus.edu.iq

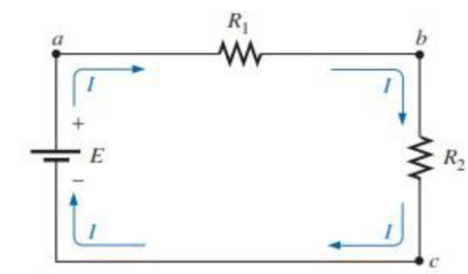
Al-Mustaqbal University
College Of Engineering Technology
Department Of Cyber Security Techniques Engineering
Class: 1st
Subject: fundamental of electrical engineering
Lecturer: Dr. Rami Qays Malik
1st term – Lecture: 3- Series & Parallel Circuits

SERIES DC CIRCUITS

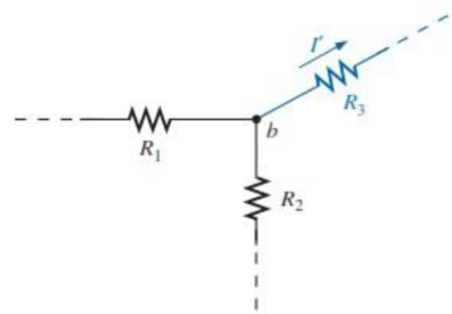
A **circuit** consists of any number of elements joined at terminal points, providing at least one closed path through which charge can flow. The circuit of Fig. 2.1(a) has three elements joined at three terminal points (*a, b, and c) to provide a closed path for the current I.*

Two elements are in series if
1.They have only one terminal in common (i.e., one lead of one is connected to only one lead of the other).
2.The common point between the two elements is not connected to another current-carrying element.

If the circuit of Fig. 2.1(a) is modified such that a current-carrying resistor R_3 is introduced, as shown in Fig. 2.1(b), the resistors R_1 *and* R_2 are no longer in series due to a violation of number 2 of the above definition of series elements.



(a) Series circuit



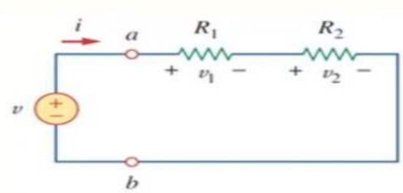
(b) R_1 and R_2 are not in series

Fig.2.1
(a) Series circuit; (b) situation in which R1 and R2 are not in series.

2.5 Series Resistors and Voltage Division (1)

The two resistors are in series, since the same current i flows in both of them.

From Ohm's law $v_1 = iR_1$ $v_2 = iR_2$

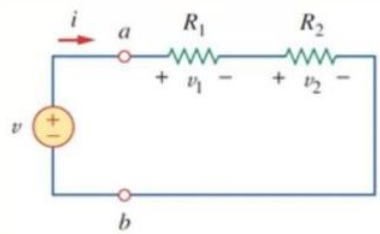


نستنتج من هاتين المعادلتين ان
الجهد يتناسب طرديا مع المقاومة
في حالة التوصيل على التوالي.

Email: rami.qays@uomus.edu.iq

2.5 Series Resistors and Voltage Division (1)

The two resistors are in series, since the same current i flows in both of them.

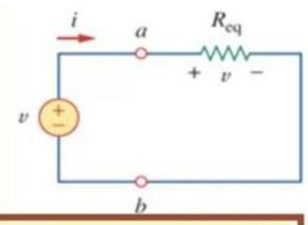


From Ohm's law $\quad v_1 = iR_1 \qquad v_2 = iR_2$

Apply KVL to the loop $\quad -v + v_1 + v_2 = 0$

$$v = v_1 + v_2 = i(R_1 + R_2)$$

$$v = iR_{eq}$$

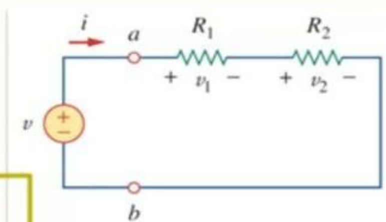


$$\boldsymbol{R_{eq} = R_1 + R_2}$$

The equivalent resistance of any number of resistors connected in a series is the sum of the individual resistances.

2.5 Series Resistors and Voltage Division (2)

Voltage Division: The voltage across each resistor



$$v_1 = \frac{R_1}{R_1 + R_2} v \qquad v_2 = \frac{R_2}{R_1 + R_2} v$$

$$v_1 = iR_1$$

$$v_2 = iR_2$$

$$i = \frac{v}{R_1 + R_2}$$

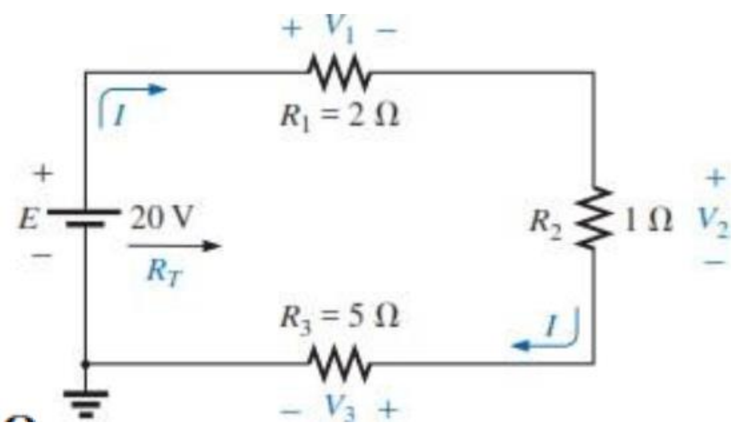
Notice that the source voltage v is divided among the resistors in direct proportion to their resistances; the larger the resistance, the larger the voltage drop.

EXAMPLE:1

a. Find the total resistance for the series circuit shown.

b. Calculate the source current I

c. Determine the voltages V_1 V_2 and V_3



a. $R_T = R_1 + R_2 + R_3 = 2\ \Omega + 1\ \Omega + 5\ \Omega = \mathbf{8\ \Omega}$

b. $I_s = \dfrac{E}{R_T} = \dfrac{20\ \text{V}}{8\ \Omega} = \mathbf{2.5\ A}$

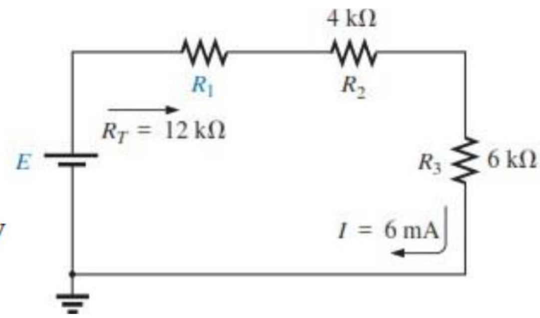
c. $V_1 = IR_1 = (2.5\ \text{A})(2\ \Omega) = \mathbf{5\ V}$
$V_2 = IR_2 = (2.5\ \text{A})(1\ \Omega) = \mathbf{2.5\ V}$
$V_3 = IR_3 = (2.5\ \text{A})(5\ \Omega) = \mathbf{12.5\ V}$

Email: rami.qays@uomus.edu.iq

EXAMPLE : 2

Given R_T and I, calculate R_1 and E for the circuit shown.

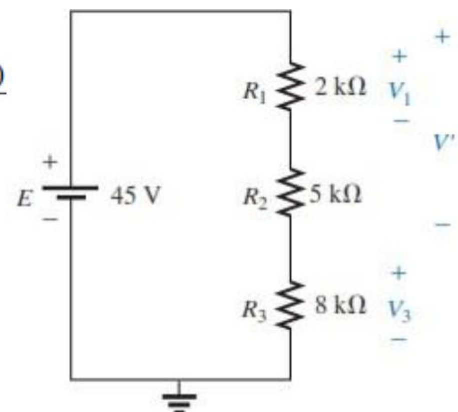
$$R_T = R_1 + R_2 + R_3$$
$$12\ \text{k}\Omega = R_1 + 4\ \text{k}\Omega + 6\ \text{k}\Omega$$
$$R_1 = 12\ \text{k}\Omega - 10\ \text{k}\Omega = \mathbf{2\ k\Omega}$$
$$E = IR_T = (6 \times 10^{-3}\ \text{A})(12 \times 10^{3}\ \Omega) = \mathbf{72\ V}$$



EXAMPLE: 3

Using the voltage divider rule, determine the voltages V_1 and V_3 for the series circuit shown.

$$V_1 = \frac{R_1E}{R_T} = \frac{(2\ \text{k}\Omega)(45\ \text{V})}{2\ \text{k}\Omega + 5\ \text{k}\Omega + 8\ \text{k}\Omega} = \frac{(2\ \text{k}\Omega)(45\ \text{V})}{15\ \text{k}\Omega}$$
$$= \frac{(2 \times 10^{3}\ \Omega)(45\ \text{V})}{15 \times 10^{3}\ \Omega} = \frac{90\ \text{V}}{15} = \mathbf{6\ V}$$
$$V_3 = \frac{R_3E}{R_T} = \frac{(8\ \text{k}\Omega)(45\ \text{V})}{15\ \text{k}\Omega} = \frac{(8 \times 10^{3}\ \Omega)(45\ \text{V})}{15 \times 10^{3}\ \Omega}$$
$$= \frac{360\ \text{V}}{15} = \mathbf{24\ V}$$

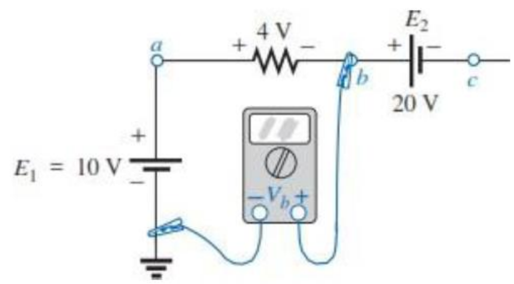


Al-Mustaqbal University
College Of Engineering Technology
Department Of Cyber Security Techniques Engineering
Class: 1st
Subject: fundamental of electrical engineering
Lecturer: Dr. Rami Qays Malik
1st term – Lecture: 3- Series & Parallel Circuits

EXAMPLE: 4

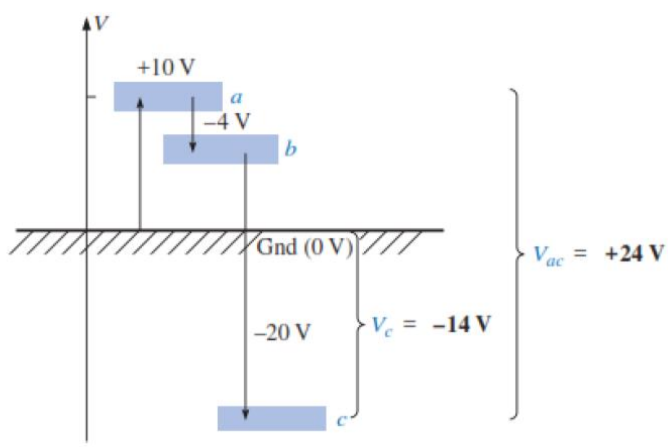
Find the voltages Vb Vc and Vac for the network shown.

$$V_b = +10\text{ V} - 4\text{ V} = \mathbf{6\text{ V}}$$

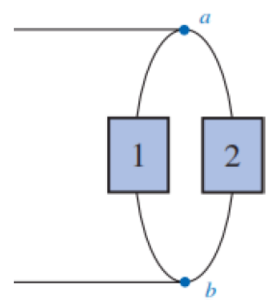


$$V_c = V_b - 20\text{ V} = 6\text{ V} - 20\text{ V} = \mathbf{-14\text{ V}}$$

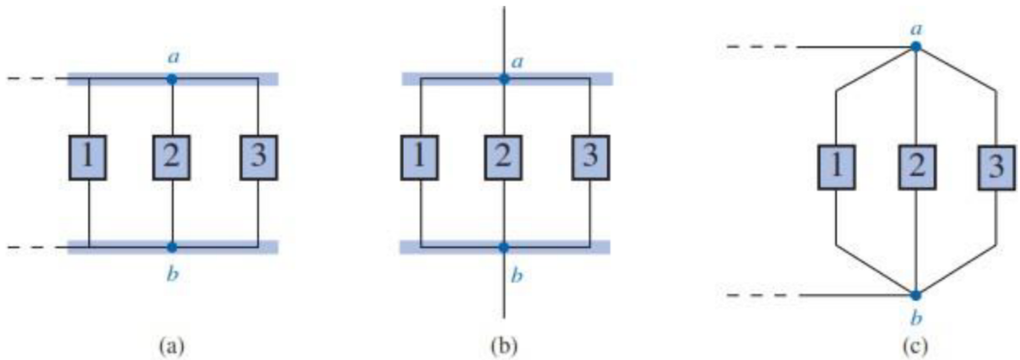
$$V_{ac} = V_a - V_c = 10\text{ V} - (-14\text{ V}) = \mathbf{24\text{ V}}$$



PARALLEL DC CIRCUITS



Two elements, branches, or networks are in parallel if they have two points in common.

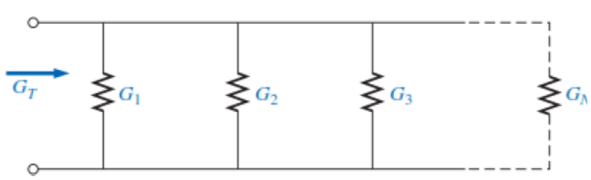


Different ways in which three parallel elements may appear.

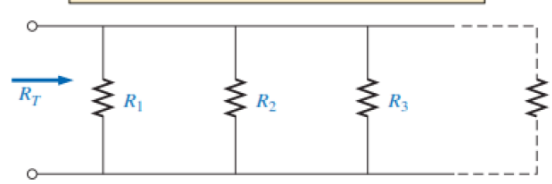
TOTAL CONDUCTANCE AND RESISTANCE

Recall that for series resistors, the total resistance is the sum of the resistor values.
For parallel elements, the total conductance is the sum of the individual conductances.

$$G_T = G_1 + G_2 + G_3 + \cdots + G_N$$



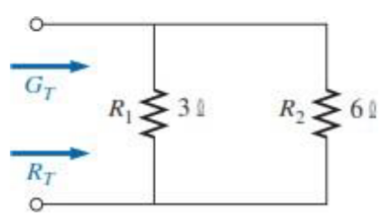
$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_N}$$



EXAMPLE 3.1 Determine the total conductance and resistance for the parallel network of Fig. shown.

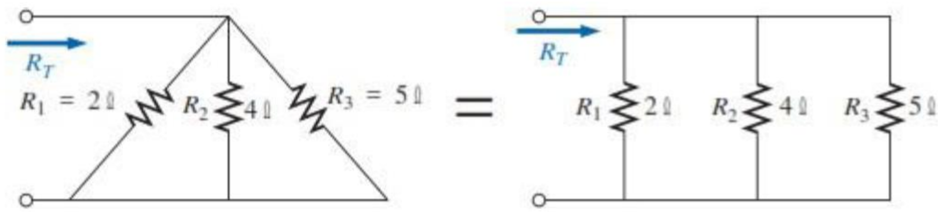
$$G_T = G_1 + G_2 = \frac{1}{3\,\Omega} + \frac{1}{6\,\Omega} = 0.333\text{ S} + 0.167\text{ S} = \mathbf{0.5\text{ S}}$$

and $$R_T = \frac{1}{G_T} = \frac{1}{0.5\text{ S}} = \mathbf{2\,\Omega}$$



EXAMPLE: 5

Determine the total resistance for the network of Fig. shown



$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$= \frac{1}{2\,\Omega} + \frac{1}{4\,\Omega} + \frac{1}{5\,\Omega} = 0.5\text{ S} + 0.25\text{ S} + 0.2\text{ S}$$

$$= 0.95\text{ S}$$

and $$R_T = \frac{1}{0.95\text{ S}} = \mathbf{1.053\ \Omega}$$

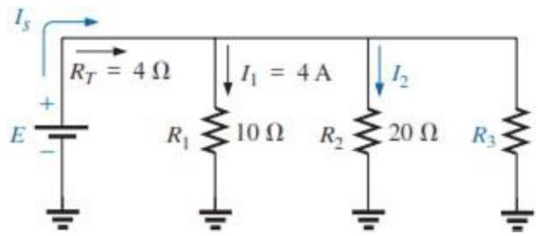
The total resistance of parallel resistors is always less than the value of the smallest resistor.

Al-Mustaqbal University
College Of Engineering Technology
Department Of Cyber Security Techniques Engineering
Class: 1st
Subject: fundamental of electrical engineering
Lecturer: Dr. Rami Qays Malik
1st term – Lecture: 3- Series & Parallel Circuits

EXAMPLE: 6

Given the information provided in Fig. shown

a. Determine R_3.
b. Calculate E.
c. Find I_s.
d. Find I_2.
e. Determine P_2.



a.
$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$
$$\frac{1}{4\,\Omega} = \frac{1}{10\,\Omega} + \frac{1}{20\,\Omega} + \frac{1}{R_3}$$
$$0.25\text{ S} = 0.1\text{ S} + 0.05\text{ S} + \frac{1}{R_3}$$
$$0.25\text{ S} = 0.15\text{ S} + \frac{1}{R_3}$$
$$\frac{1}{R_3} = 0.1\text{ S}$$
$$R_3 = \frac{1}{0.1\text{ S}} = \mathbf{10\,\Omega}$$

b. $E = V_1 = I_1R_1 = (4\text{ A})(10\,\Omega) = \mathbf{40\text{ V}}$

c. $I_s = \dfrac{E}{R_T} = \dfrac{40\text{ V}}{4\,\Omega} = \mathbf{10\text{ A}}$

d. $I_2 = \dfrac{V_2}{R_2} = \dfrac{E}{R_2} = \dfrac{40\text{ V}}{20\,\Omega} = \mathbf{2\text{ A}}$

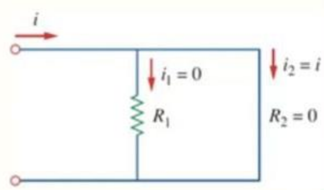
e. $P_2 = I_2^2R_2 = (2\text{ A})^2(20\,\Omega) = \mathbf{80\text{ W}}$

2.6 Parallel Resistors (Extreme Cases)

Extreme Case (1) $R_2=0$ *i.e.* R_2 is a short circuit

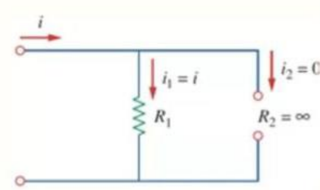
$$i_1 = 0, \qquad i_2 = i$$

1. The equivalent resistance $R_{eq} = 0$.
2. The entire current flows through the short circuit.



Extreme Case (2) $R_2=\infty$ *i.e.* R_2 is an open circuit

1. The equivalent resistance $R_{eq} = R_1$.
2. The entire current flows through the path of least resistance.



Al-Mustaqbal University
College Of Engineering Technology
Department Of Cyber Security Techniques Engineering
Class: 1st
Subject: fundamental of electrical engineering
Lecturer: Dr. Rami Qays Malik
1st term – Lecture: 3- Series & Parallel Circuits

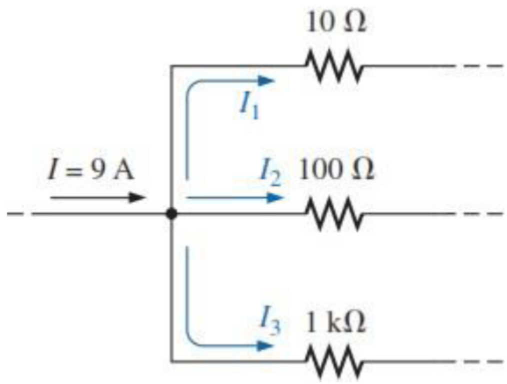
CURRENT DIVIDER RULE

-The majority of the current will pass through the smallest resistor of 10 Ω , and the least current will pass through the 1 kΩ resistor.

-In fact, the current through the 100 Ω resistor will also exceed that through the 1 k Ω resistor.

-By recognizing that the resistance of the 100 Ω is 10 times that of the 10 Ω resistor. The result is a current through the 10 Ω resistor that is 10 times that of the 100 Ω resistor.

-Similarly, the current through the 100 Ω resistor is 10 times that through the 1 kΩ resistor.



For two parallel elements of equal value, the current will divide equally.

For parallel elements with different values, the smaller the resistance, the greater the share of input current.

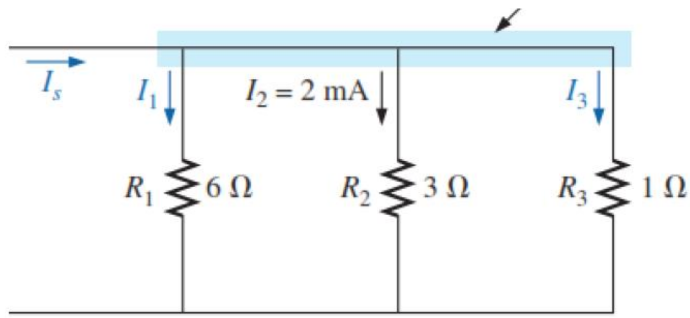
For parallel elements of different values, the current will split with a ratio equal to the inverse of their resistor values.

Email: rami.qays@uomus.edu.iq

Al-Mustaqbal University
College Of Engineering Technology
Department Of Cyber Security Techniques Engineering
Class: 1st
Subject: fundamental of electrical engineering
Lecturer: Dr. Rami Qays Malik
1st term – Lecture: 3- Series & Parallel Circuits

EXAMPLE: 7

a. Determine currents I_1 and I_3 for the network in Fig.
b. Find the source current Is



a. Since R_1 is twice R_2, the current I_1 must be one-half I_2, and

$$I_1 = \frac{I_2}{2} = \frac{2\text{ mA}}{2} = \mathbf{1\ mA}$$

Since R_2 is three times R_3, the current I_3 must be three times I_2, and

$$I_3 = 3I_2 = 3(2\text{ mA}) = \mathbf{6\ mA}$$

b. Applying Kirchhoff's current law:

$$\Sigma I_i = \Sigma I_o$$
$$I_s = I_1 + I_2 + I_3$$
$$I_s = 1\text{ mA} + 2\text{ mA} + 6\text{ mA} = \mathbf{9\ mA}$$