College of Engineering
Dept. of the electrical power
and Machine engineering
Subject / Electrical Eng. Fundamental I

stage / first
Date: 21/11/2017
Lecture:4
Time/ 2 hours

Series dc Circuits

SERIES RESISTORS

In equation form for any number (N) of resistors,

$$\boxed{R_T = R_1 + R_2 + R_3 + R_4 + \cdots + R_N}$$

SERIES CIRCUITS

- A circuit is any combination of elements that will result in a continuous flow of charge, or current, through the configuration

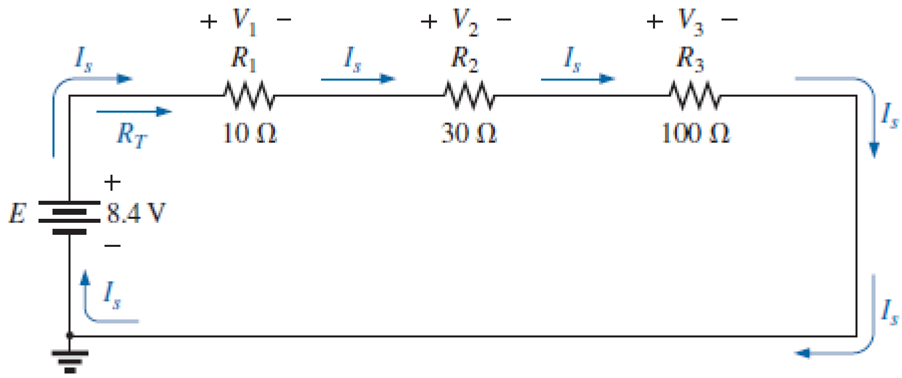
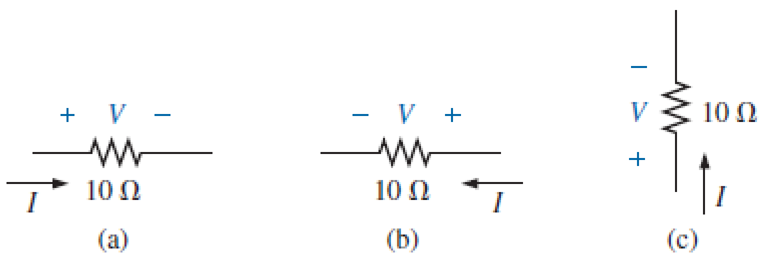


FIG. 12
Schematic representation for a dc series circuit.

- the direction of conventional current in a series dc circuit is such that it leaves the positive terminal of the supply and returns to the negative terminal, as shown in Fig. 12.
- The current is the same at every point in a series circuit. In any configuration, if two elements are in series, the current must be the same. However, if the current is the same for two adjoining elements, the elements may or may not be in series.

$$\boxed{I_s = \frac{E}{R_T}}$$

-
- the polarity of the voltage across a resistor is determined by the direction of the current



$$\boxed{\begin{aligned} V_1 &= I_1R_1 \\ V_2 &= I_2R_2 \\ V_3 &= I_3R_3 \end{aligned}}$$

FIG. 14
Inserting the polarities across a resistor as determined by the direction of the current.

Lecturer: Ammar Issa

POWER DISTRIBUTION IN A SERIES CIRCUIT

the power applied by the dc supply must equal that dissipated by the resistive elements.

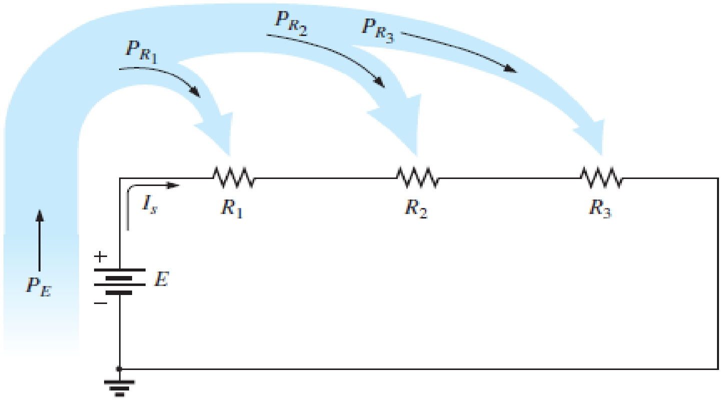


FIG. 21
Power distribution in a series circuit.

In equation form,

$$\boxed{P_E = P_{R_1} + P_{R_2} + P_{R_3}}$$

The power delivered by the supply can be determined using

$$\boxed{P_E = EI_s} \qquad \text{(watts, W)}$$

$$\boxed{P_1 = V_1 I_1 = I_1^2 R_1 = \frac{V_1^2}{R_1}} \qquad \text{(watts, W)}$$

in a series configuration, maximum power is delivered to the largest resistor

EXAMPLE 7 For the series circuit in Fig. 22 (all standard values):

a. Determine the total resistance R_T.
b. Calculate the current I_s.
c. Determine the voltage across each resistor.
d. Find the power supplied by the battery.
e. Determine the power dissipated by each resistor.
f. Comment on whether the total power supplied equals the total power dissipated.

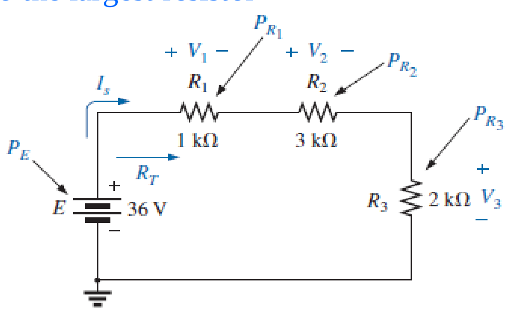


FIG. 22
Series circuit to be investigated in Example 7.

Solutions:

a. $R_T = R_1 + R_2 + R_3$
$= 1\text{ k}\Omega + 3\text{ k}\Omega + 2\text{ k}\Omega$
$R_T = \mathbf{6\text{ k}\Omega}$

b. $I_s = \dfrac{E}{R_T} = \dfrac{36\text{ V}}{6\text{ k}\Omega} = \mathbf{6\text{ mA}}$

c. $V_1 = I_1R_1 = I_sR_1 = (6\text{ mA})(1\text{ k}\Omega) = \mathbf{6\text{ V}}$
$V_2 = I_2R_2 = I_sR_2 = (6\text{ mA})(3\text{ k}\Omega) = \mathbf{18\text{ V}}$
$V_3 = I_3R_3 = I_sR_3 = (6\text{ mA})(2\text{ k}\Omega) = \mathbf{12\text{ V}}$

d. $P_E = EI_s = (36\text{ V})(6\text{ mA}) = \mathbf{216\text{ mW}}$

e. $P_1 = V_1I_1 = (6\text{ V})(6\text{ mA}) = \mathbf{36\text{ mW}}$
$P_2 = I_2^2R_2 = (6\text{ mA})^2(3\text{ k}\Omega) = \mathbf{108\text{ mW}}$
$P_3 = \dfrac{V_3^2}{R_3} = \dfrac{(12\text{ V})^2}{2\text{ k}\Omega} = \mathbf{72\text{ mW}}$

f. $P_E = P_{R_1} + P_{R_2} + P_{R_3}$
$216\text{ mW} = 36\text{ mW} + 108\text{ mW} + 72\text{ mW} = \mathbf{216\text{ mW}}$ (checks)

VOLTAGE SOURCES IN SERIES

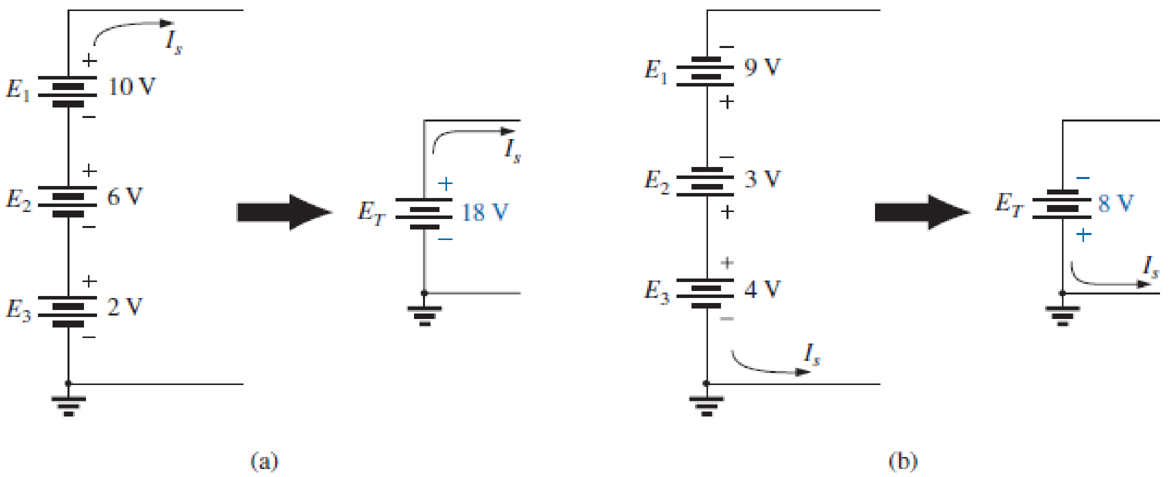


FIG. 23
Reducing series dc voltage sources to a single source.

Parallel dc Circuits

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

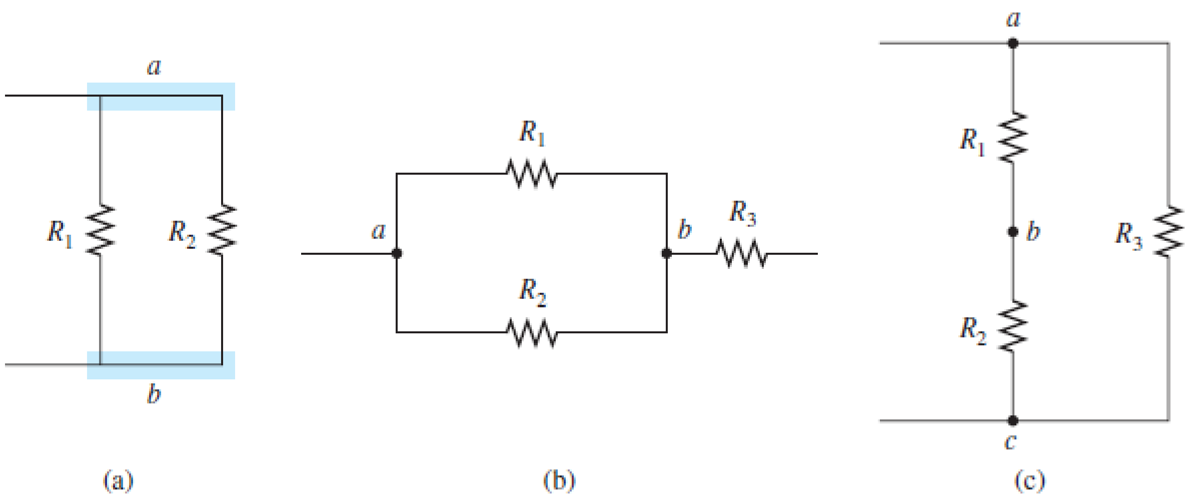


FIG. 1
(a) Parallel resistors; (b) R_1 and R_2 are in parallel; (c) R_3 is in parallel with the series combination of R_1 and R_2.

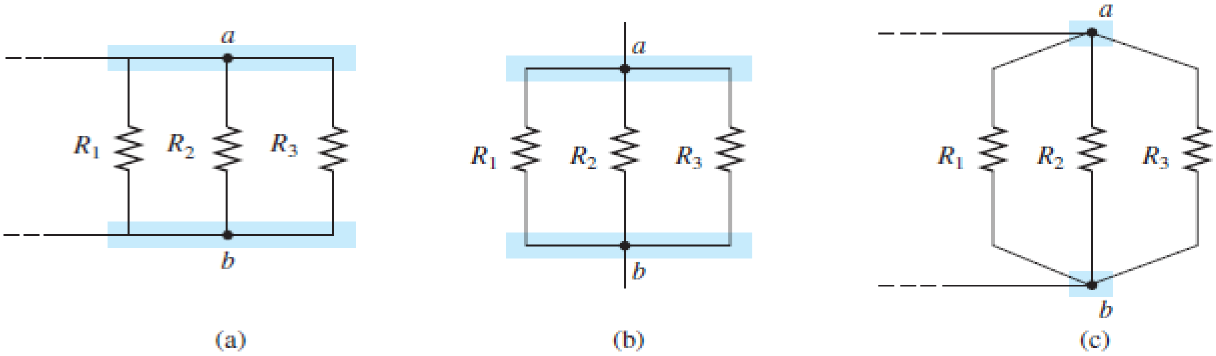


FIG. 2
Schematic representations of three parallel resistors.

For resistors in parallel as shown in Fig. 3, the total resistance is determined from the following equation:

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

Since $G = 1/R$, the equation can also be written in terms of conductance levels as follows:

$$G_T = G_1 + G_2 + G_3 + \cdots + G_N \qquad \text{(siemens, S)} \qquad (2)$$

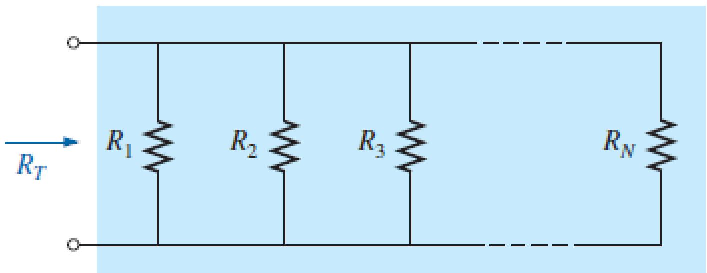


FIG. 3
Parallel combination of resistors.

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

EXAMPLE 6 Find the total resistance for the configuration in Fig. 10.

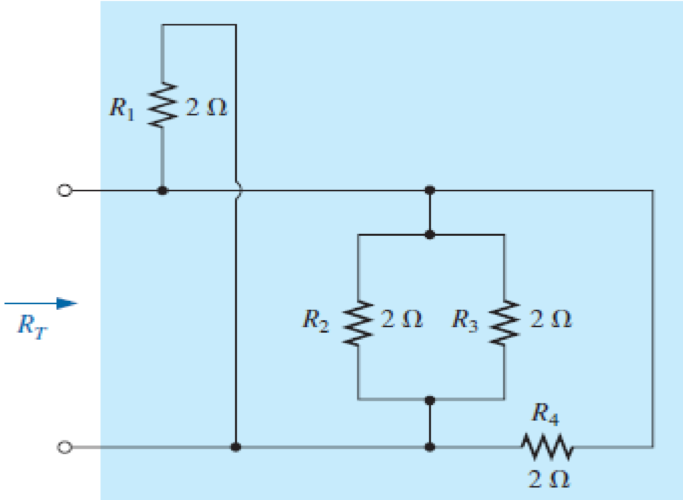


FIG. 10
Parallel configuration for Example 6.

Two Parallel Resistors

$$\boxed{R_T = \frac{R_1 R_2}{R_1 + R_2}}$$

PARALLEL CIRCUITS

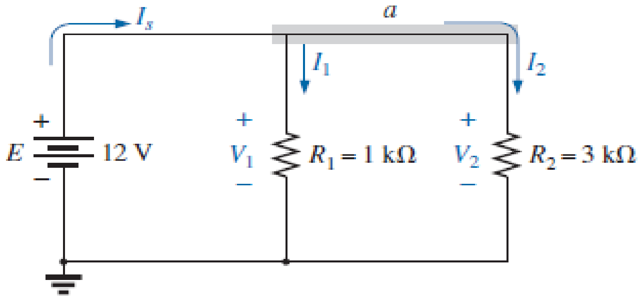


FIG. 18
Parallel network.

$$\boxed{V_1 = V_2 = E}$$

the voltage is always the same across parallel elements.
Therefore, remember that
if two elements are in parallel, the voltage across them must be the same. However, if the voltage across two neighboring elements is the same, the two elements may or may not be in parallel.

$$\boxed{I_s = \frac{E}{R_T}}$$

$$\boxed{I_1 = \frac{V_1}{R_1} = \frac{E}{R_1} \quad \text{and} \quad I_2 = \frac{V_2}{R_2} = \frac{E}{R_2}}$$

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

Multiplying both sides by the applied voltage gives

$$E\left(\frac{1}{R_T}\right) = E\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

resulting in

$$\frac{E}{R_T} = \frac{E}{R_1} + \frac{E}{R_2}$$

Then note that $E/R_1 = I_1$ and $E/R_2 = I_2$ to obtain

$$\boxed{I_s = I_1 + I_2}$$

For single-source parallel networks, the source current (Is) is always equal to the sum of the individual branch currents.

POWER DISTRIBUTION IN A PARALLEL CIRCUIT

for any network composed of resistive elements, the power applied by the battery will equal that dissipated by the resistive elements

For the parallel circuit in Fig. 28:

$$\boxed{P_E = P_{R_1} + P_{R_2} + P_{R_3}}$$

which is exactly the same as obtained for the series combination.

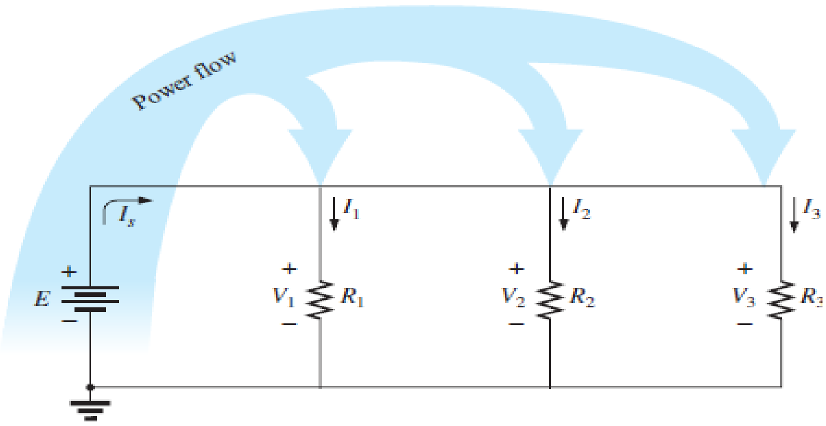


FIG. 28
Power flow in a dc parallel network.