

Series Direct (DC) current circuit

Introduction

Introduction

INTRODUCTION

Two types of current are readily available to the consumer today.

- One is *direct current (dc)*, in which ideally the flow of charge (current) does not change in magnitude (or direction) with time.
- The other is *sinusoidal alternating current (ac)*, in which the flow of charge is continually changing in magnitude (and direction) with time.

Series DC Circuit

Series dc Circuits

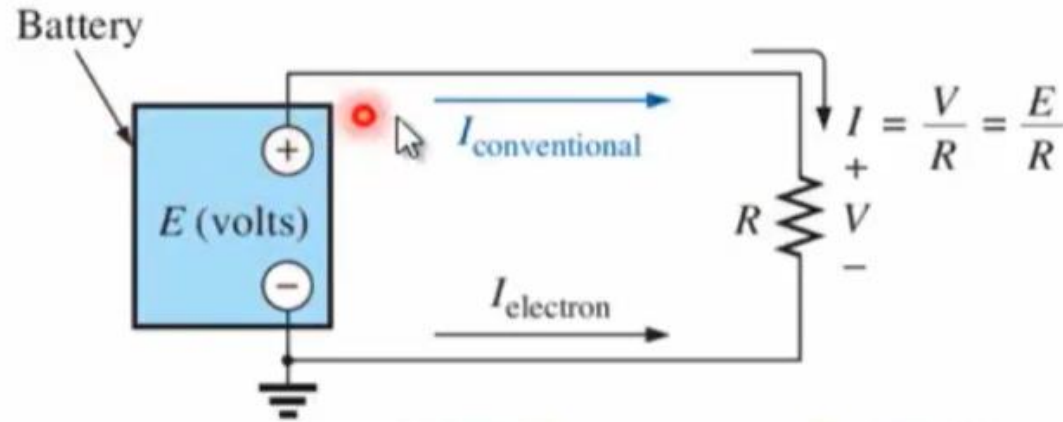


FIG. 5.1 Introducing the basic components of an electric circuit.

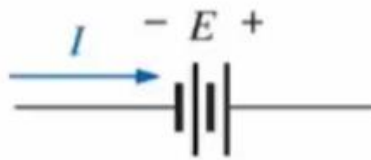


FIG. 5.2 Defining the direction of conventional flow for single-source dc circuits.

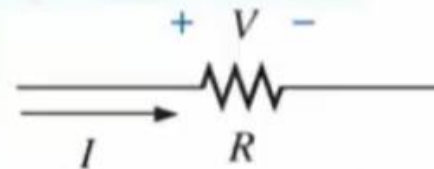


FIG. 5.3 Defining the polarity resulting from conventional current I through a resistive

Series Resistors

SERIES RESISTORS

- Before the series connection is described, first recognize that every fixed resistor has only two terminals to connect in a configuration—it is therefore referred to as a **two-terminal device**.

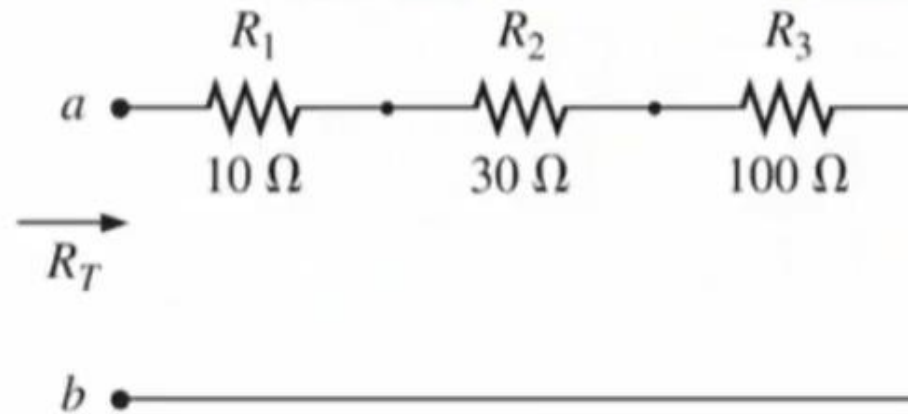
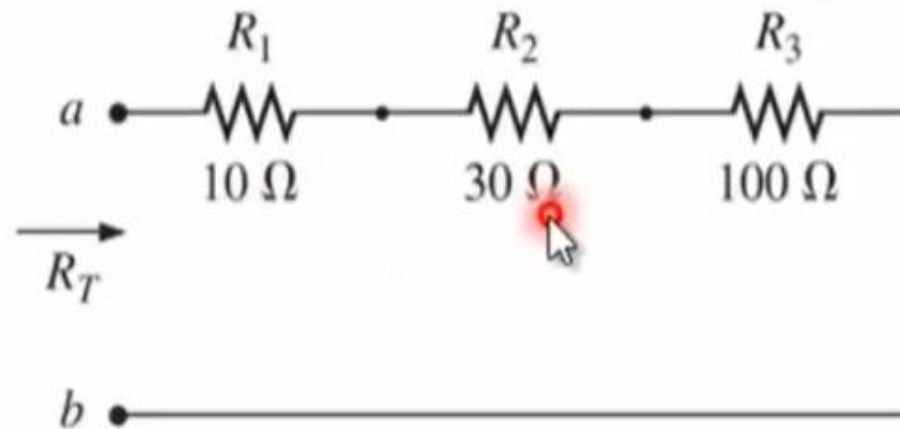


FIG. 5.4 *Series connection of resistors.*

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SERIES RESISTORS

The total resistance of a series circuit is the sum of the resistance levels.



$$R_T = R_1 + R_2 + R_3 + R_4 + \cdots + R_N$$

$$R_T = 10\ \Omega + 30\ \Omega + 100\ \Omega = 140\ \Omega$$

Example

SERIES RESISTORS

Example

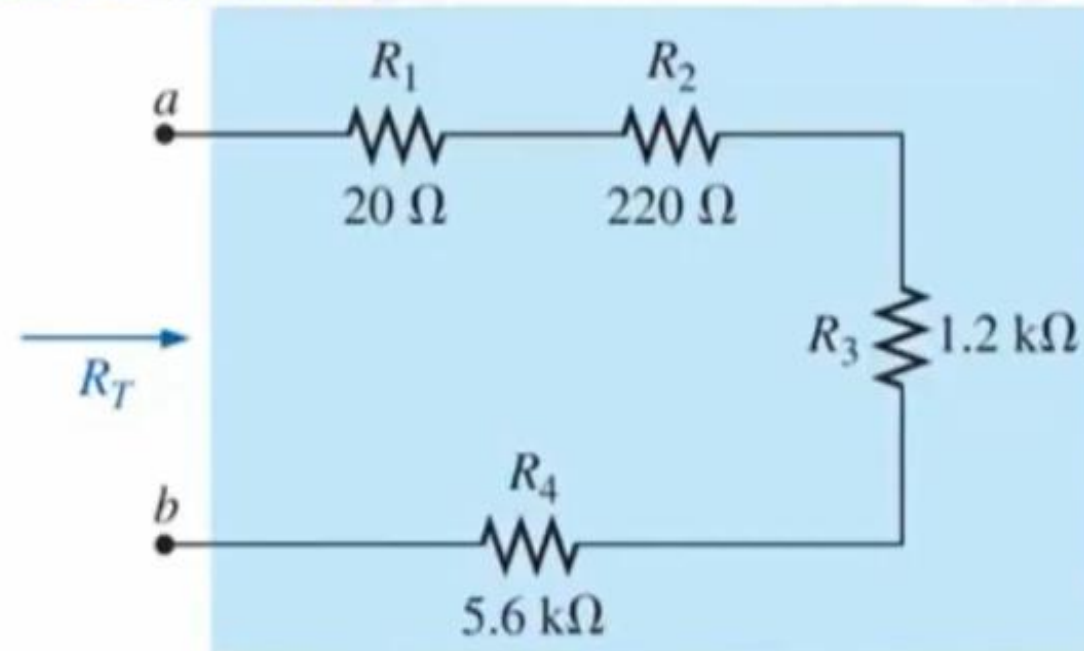


FIG. 5.5 Series connection of resistors.

$$R_T = 20\ \Omega + 220\ \Omega + 1200\ \Omega + 5600\ \Omega = 7040\ \Omega = 7.04\ \text{k}\Omega$$

Examples – equal resistors

SERIES RESISTORS

If all resistors are equal, then :

$$R_T = NR$$

Example

$$R_T = 4 \times 3.3 \text{ k}\Omega = 13.2 \text{ k}\Omega$$

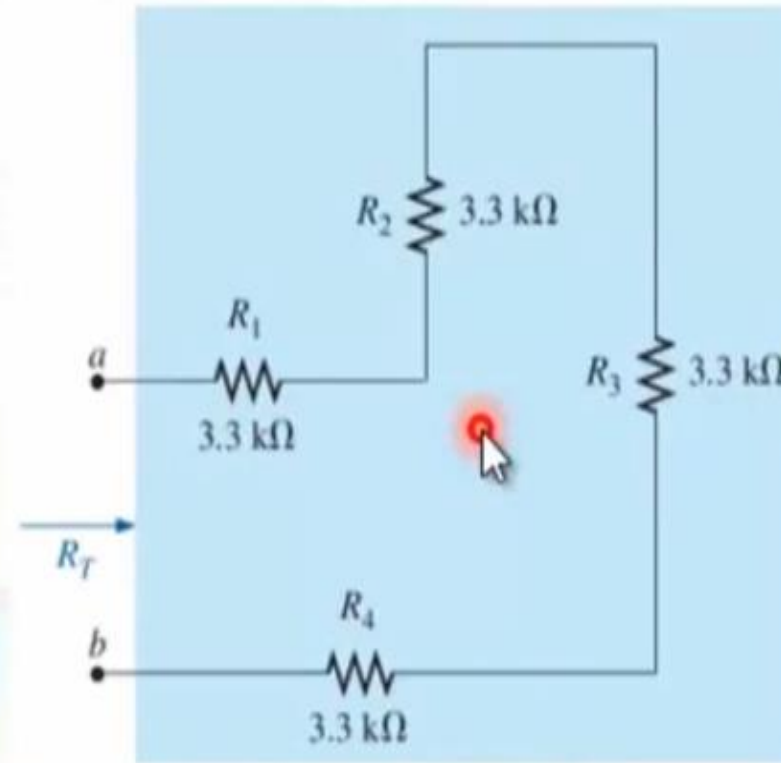


FIG. 5.6 Series connection of four resistors of the same value (Example 5.2).

Changing resistors position

SERIES RESISTORS

The total resistance of resistors in series is unaffected by the order in which they are connected.

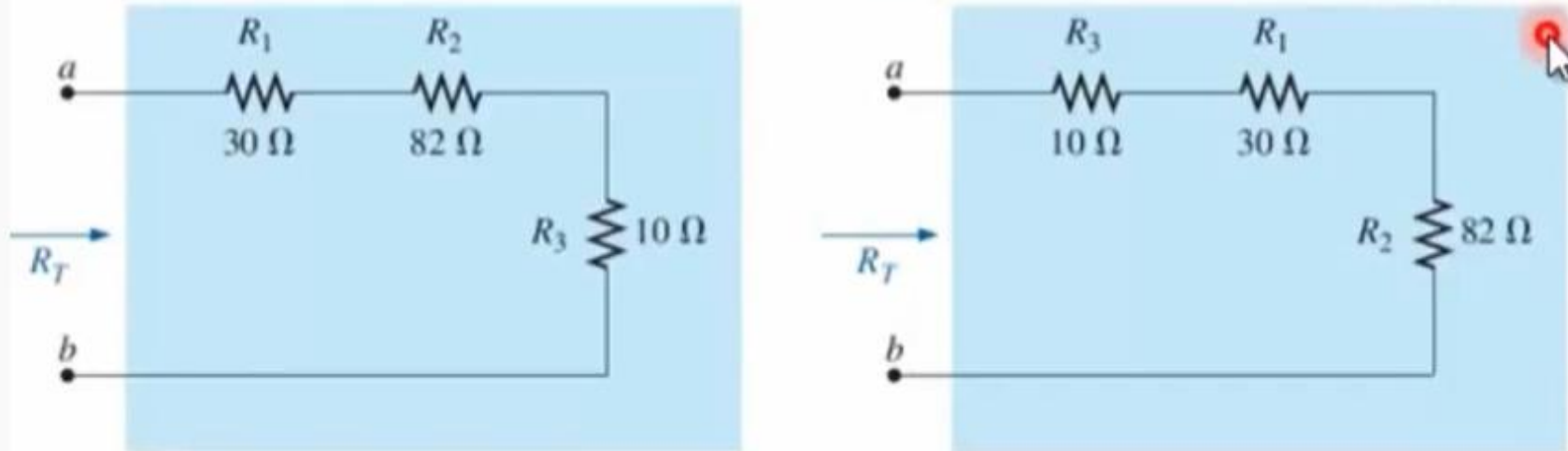
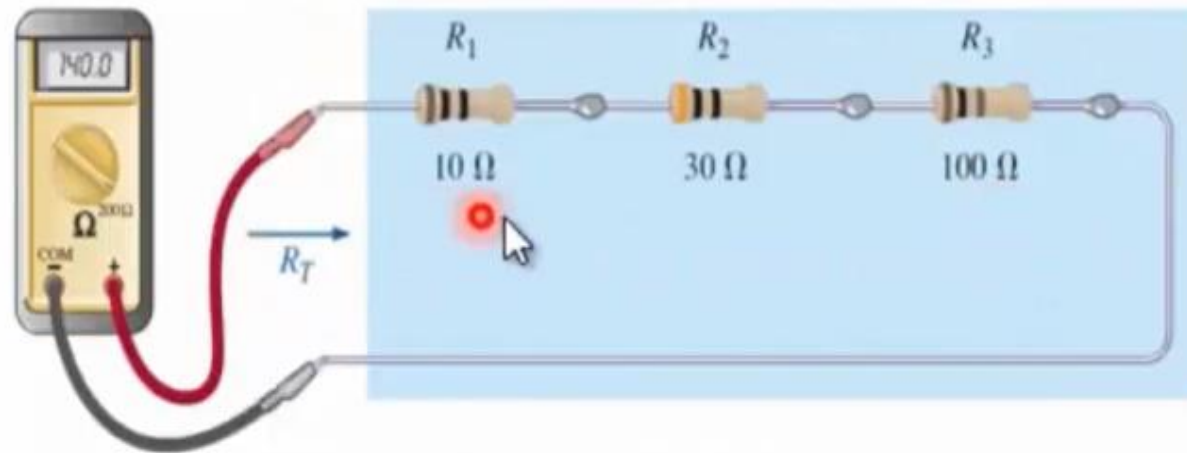


FIG. 5.7 Two series combinations of the same elements with the same total resistance.

Instrumentation

SERIES RESISTORS Instrumentation

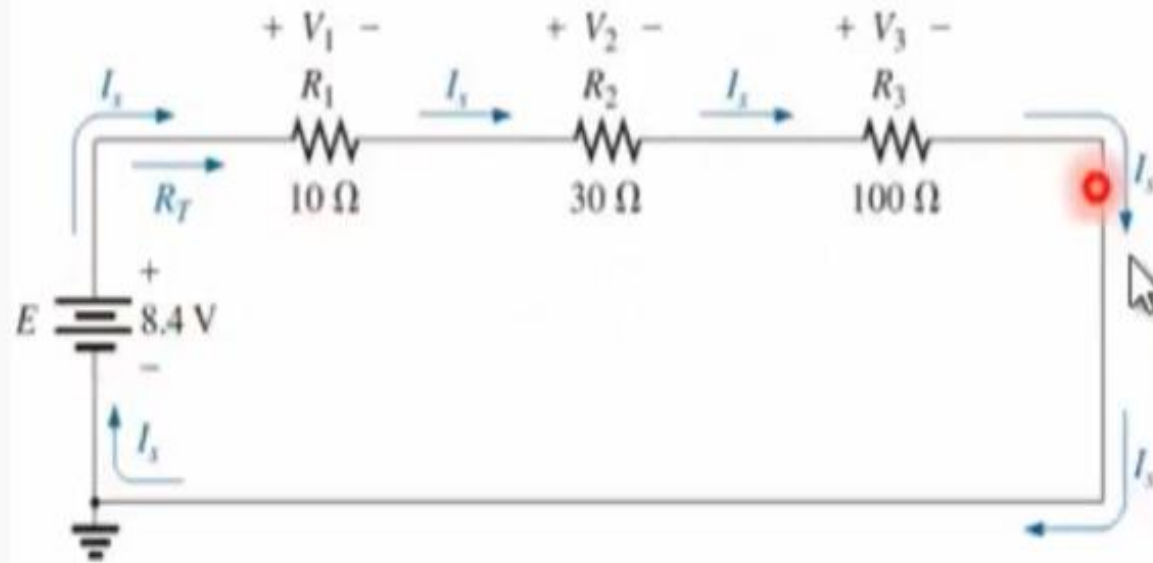
- The total resistance of any configuration can be measured by simply connecting an ohmmeter across the access terminals.
- Since there is no polarity associated with resistance, either lead can be connected to point a, with the other lead connected to point b.



Series circuit

SERIES CIRCUITS

If we now take an 8.4 V dc supply and connect it in series with the series resistors in Fig. 5.9, we have the series circuit in Fig. 5.9.



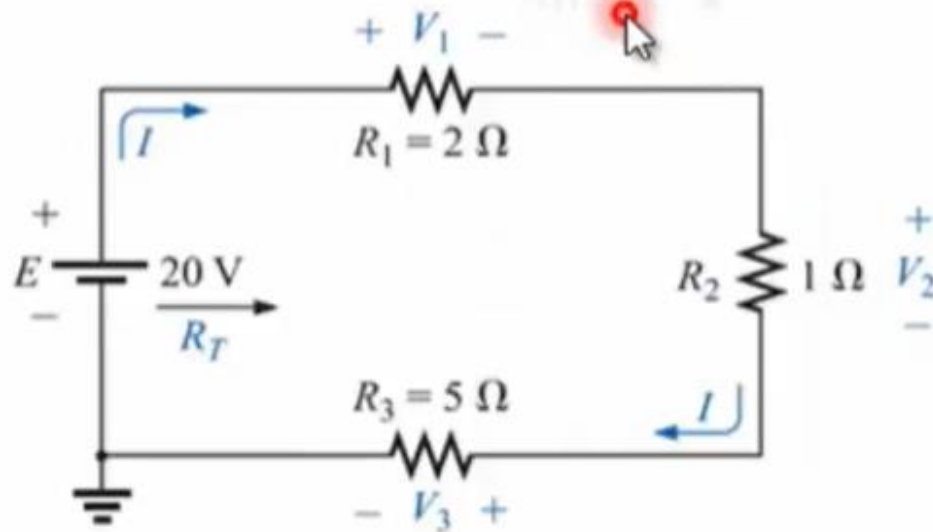
$$\begin{aligned} I_s &= E / R_T \\ &= 8.4 \text{ V} / 140 \, \Omega \\ &= 0.06 \text{ A} \end{aligned}$$

Examples

Series dc Circuits

EXAMPLE 5.1

- Find the total resistance for the series circuit of Fig.
- Calculate the source current I_s .
- Determine the voltages V_1 , V_2 , and V_3 .



Examples

Series dc Circuits

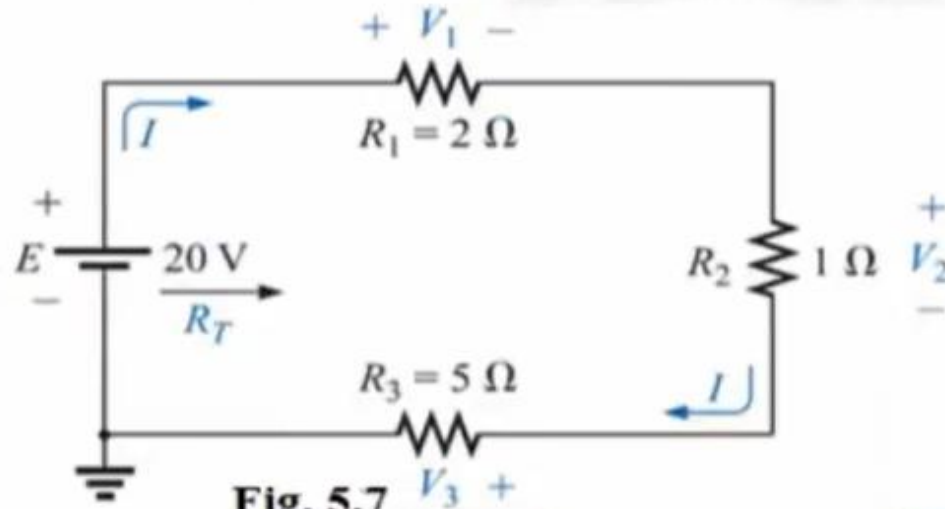


Fig. 5.7

Solutions:

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

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

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

Examples

Series dc Circuits

EXAMPLE 5.3 Given R_T and I , calculate R_1 and E for the circuit of Fig. 5.9.

Solution:

$$R_T = R_1 + R_2 + R_3$$

$$12 \text{ k}\Omega = R_1 + 4 \text{ k}\Omega + 6 \text{ k}\Omega$$

$$R_1 = 12 \text{ k}\Omega - 10 \text{ k}\Omega = \mathbf{2 \text{ k}\Omega}$$

$$E = IR_T = (6 \times 10^{-3} \text{ A})(12 \times 10^3 \Omega) = \mathbf{72 \text{ V}}$$

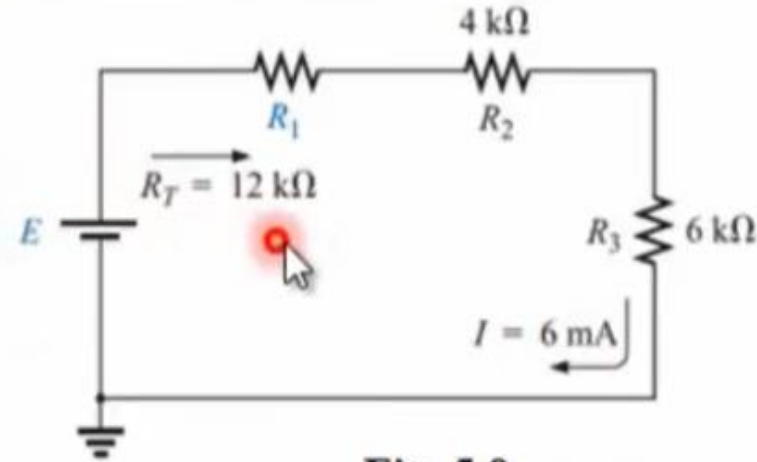


Fig. 5.9

Power distribution

POWER DISTRIBUTION IN A SERIES CIRCUIT

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

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

$$P_E = EI_s$$

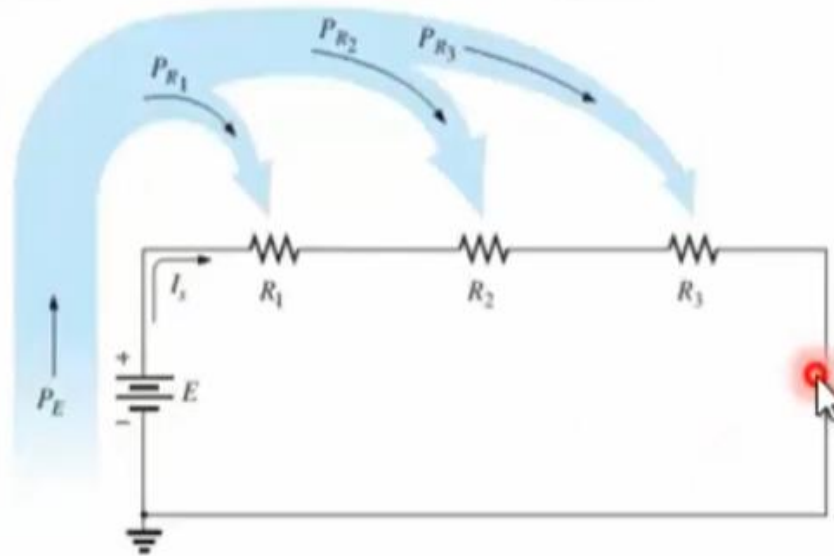
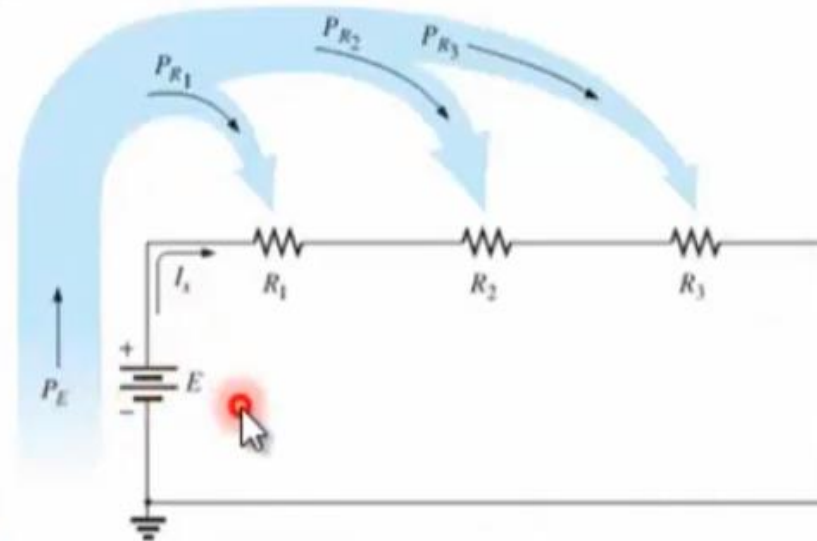


FIG. 5.10 Power distribution in a series circuit

continue

POWER DISTRIBUTION IN A SERIES CIRCUIT

The power dissipated by the resistive elements can be determined by any of the following forms (shown for resistor R_1 only)



$$P_1 = V_1 I_1 = I_1^2 R_1 = \frac{V_1^2}{R_1}$$

(watts, W)

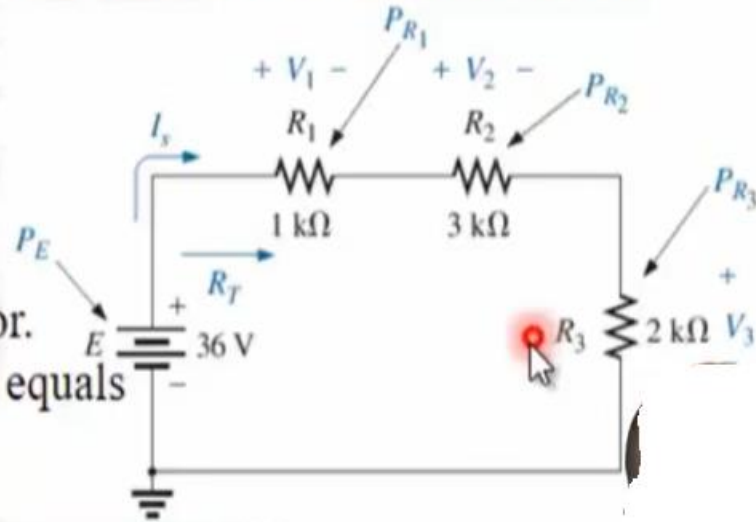
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POWER DISTRIBUTION IN A SERIES CIRCUIT

Example

For the series circuit in Fig

- Find the power supplied by the battery.
- Determine the power dissipated by each resistor.
- Comment on whether the total power supplied equals the total power dissipated.



Solutions:

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

$$P_1 = V_1 I_1 = (6\text{ V})(6\text{ mA}) = \mathbf{36\text{ mW}}$$

$$P_2 = I_2^2 R_2 = (6\text{ mA})^2 (3\text{ k}\Omega) = \mathbf{108\text{ mW}}$$

$$P_3 = \frac{V_3^2}{R_3} = \frac{(12\text{ V})^2}{2\text{ k}\Omega} = \mathbf{72\text{ mW}}$$

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

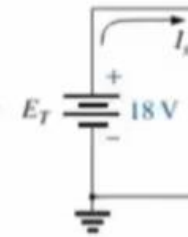
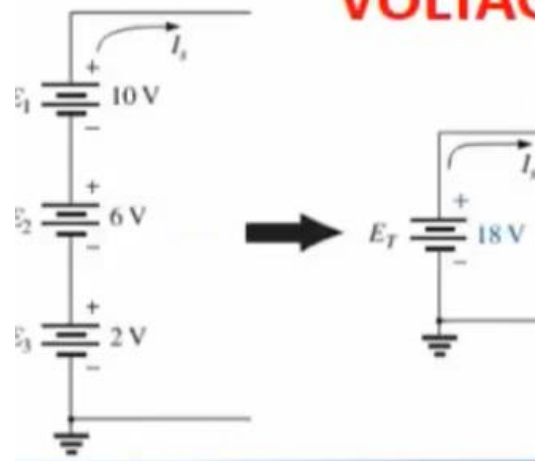
Voltage sources in series

VOLTAGE SOURCES IN SERIES

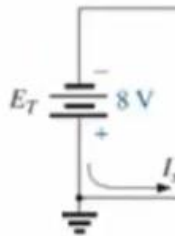
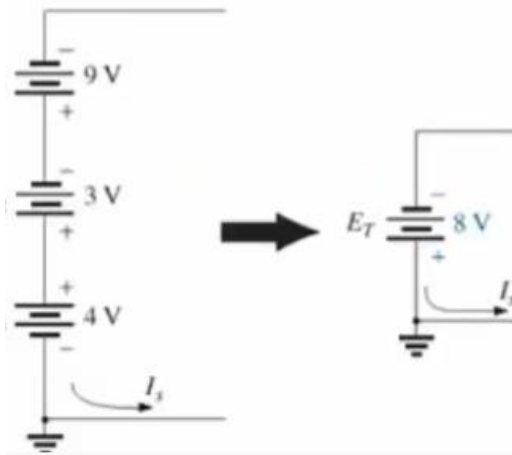
Voltage sources can be connected in series, as shown in Fig., to increase or decrease the total voltage applied to a system. The net voltage is determined by summing the sources with the same polarity and subtracting the total of the sources with the opposite polarity. The net polarity is the polarity of the larger sum.

continue

VOLTAGE SOURCES IN SERIES



$$E_T = E_1 + E_2 + E_3 = 10\text{ V} + 6\text{ V} + 2\text{ V} = 18\text{ V}$$



$$E_T = E_1 + E_2 + E_3 = 9\text{ V} + 3\text{ V} - 4\text{ V} = 8\text{ V}$$

Conclusion

Series dc Circuits

Conclusion

In this lecture, the characteristics of a series circuit has been introduced.

We too discussed how calculation the total resistance and solve for the voltage, current, and power to each of the elements