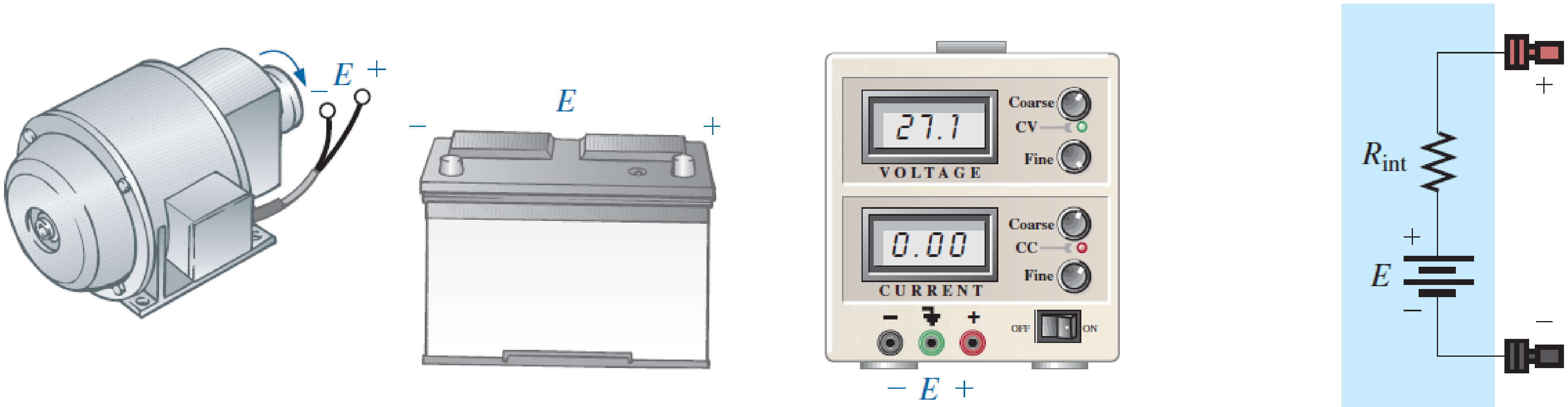
# Parallel DC Circuit

By Ariful Islam
Dept. of EEE
University of Dhaka

# VOLTAGE REGULATION AND THE INTERNAL RESISTANCE OF VOLTAGE SOURCES

*every practical (real-world) supply has an internal resistance in series with the idealized voltage source*




(a) (b)

# VOLTAGE REGULATION AND THE INTERNAL RESISTANCE OF VOLTAGE SOURCES

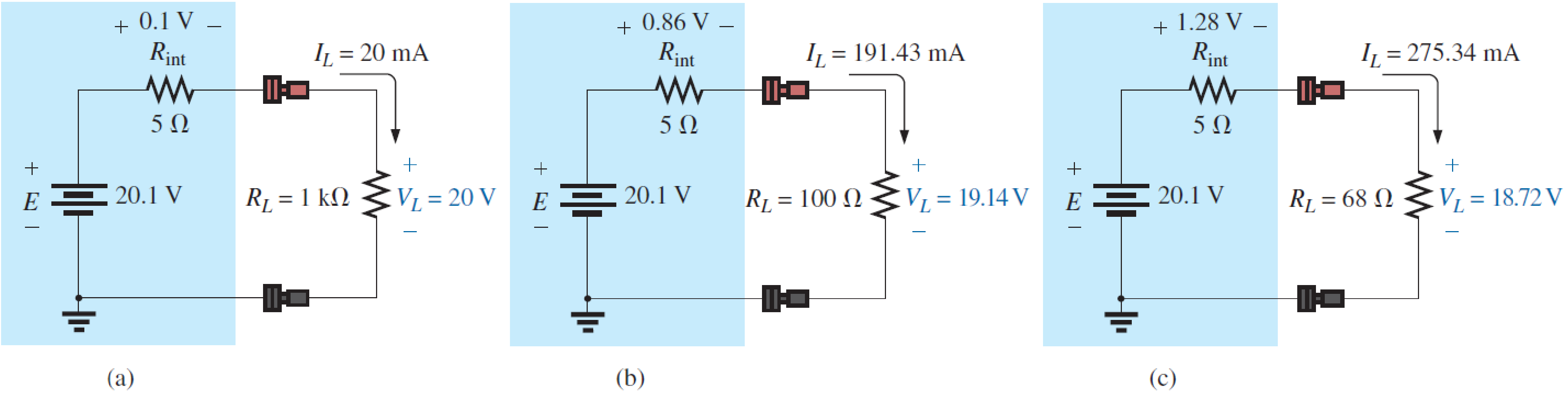



**FIG. 66**

*Demonstrating the effect of changing a load on the terminal voltage of a supply.*

# VOLTAGE REGULATION AND THE INTERNAL RESISTANCE OF VOLTAGE SOURCES

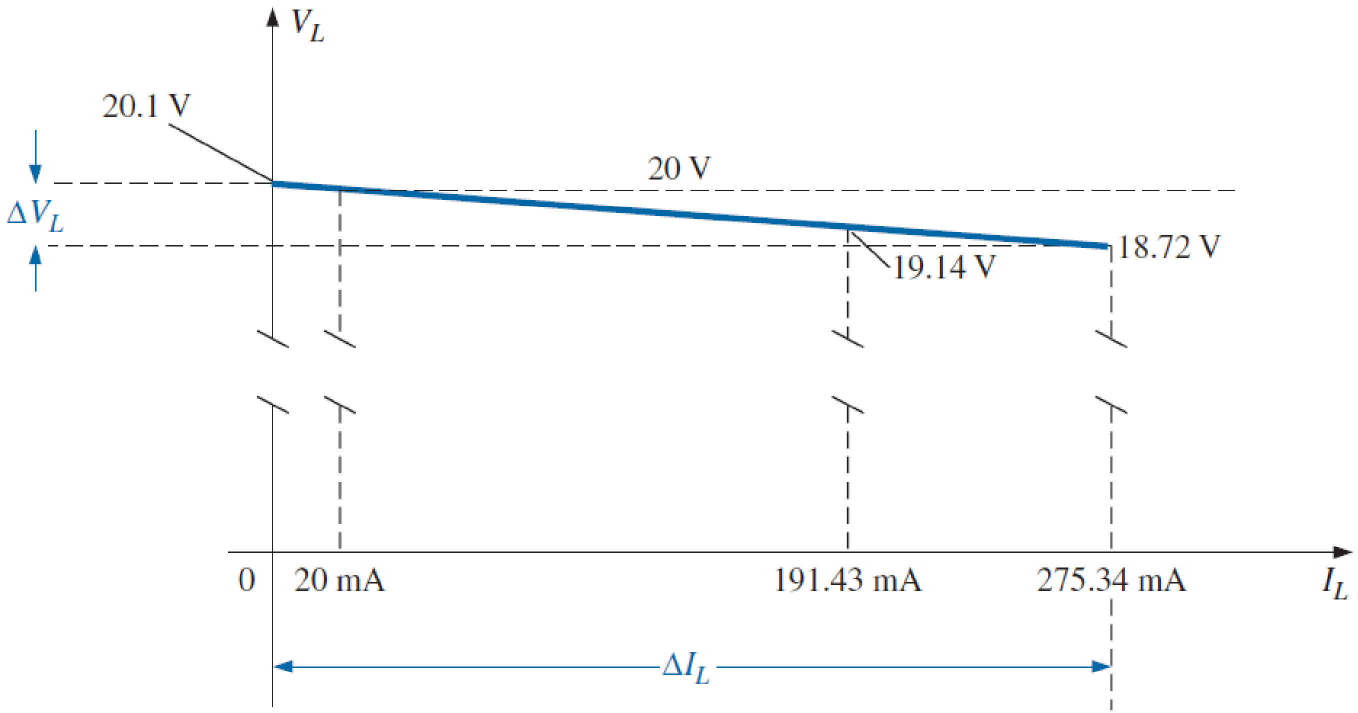



**FIG. 67**

*Plotting $V_L$ versus $I_L$ for the supply in Fig. 66.*

# VOLTAGE REGULATION AND THE INTERNAL RESISTANCE OF VOLTAGE SOURCES

$$\boxed{R_{int} = \frac{\Delta V_L}{\Delta I_L}} \qquad \text{(ohms, } \Omega\text{)} \qquad \textbf{(13)}$$

which for the plot in Fig. 67 results in

$$R_{int} = \frac{\Delta V_L}{\Delta I_L} = \frac{20.1\text{ V} - 18.72\text{ V}}{275.34\text{ mA} - 0\text{ mA}} = \frac{1.38\text{ V}}{275.34\text{ mA}} = \mathbf{5\ \Omega}$$

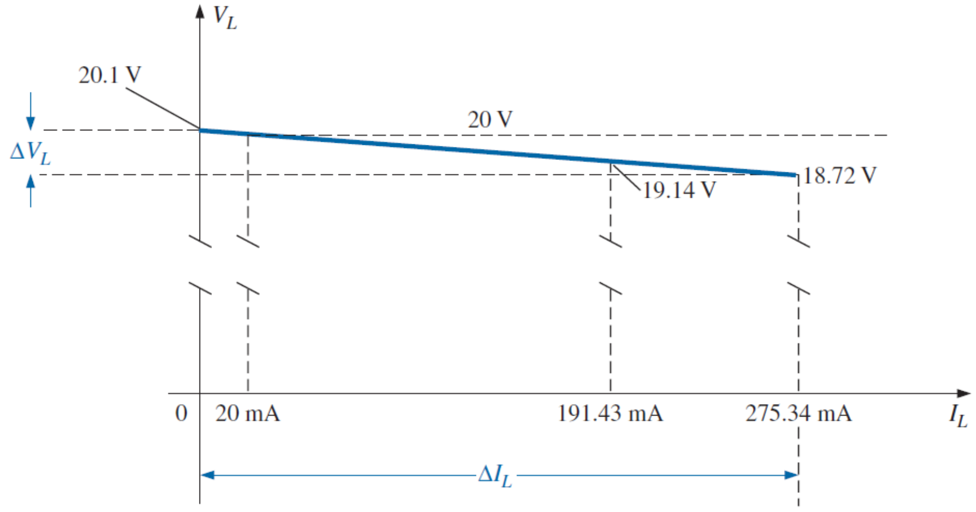



**FIG. 67**
*Plotting $V_L$ versus $I_L$ for the supply in Fig. 66.*

# VOLTAGE REGULATION AND THE INTERNAL RESISTANCE OF VOLTAGE SOURCES

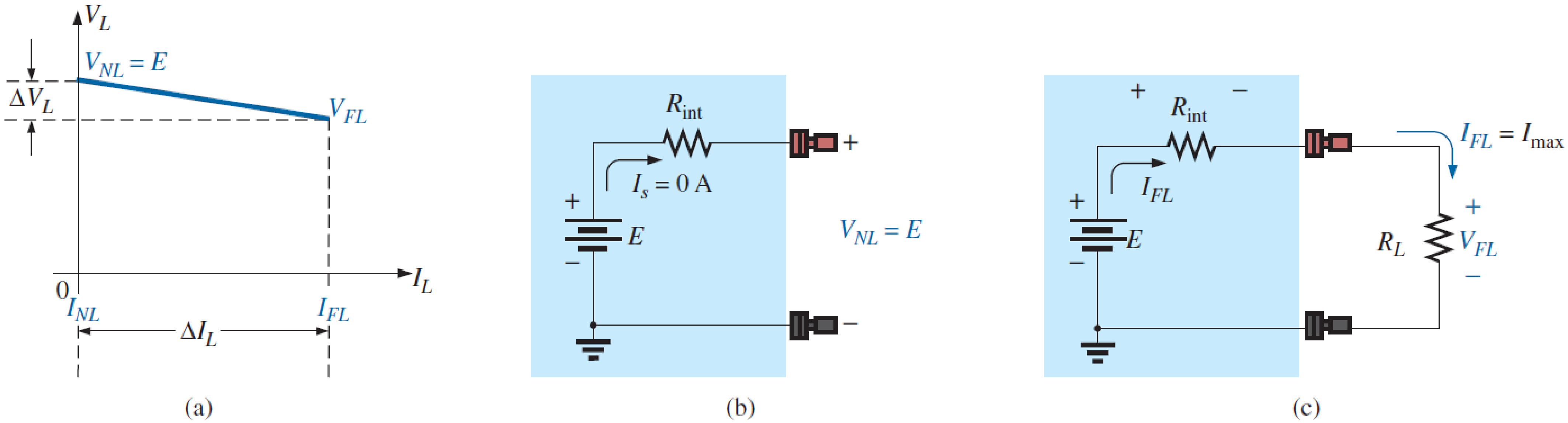



**FIG. 68**

*Defining the properties of importance for a power supply.*

# VOLTAGE REGULATION AND THE INTERNAL RESISTANCE OF VOLTAGE SOURCES

$$\boxed{VR = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\%}$$

$$VR = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\% = \frac{20.1\ \text{V} - 18.72\ \text{V}}{18.72\ \text{V}} \times 100\% \cong \mathbf{7.37\%}$$

# VOLTAGE REGULATION AND THE INTERNAL RESISTANCE OF VOLTAGE SOURCES

**EXAMPLE 28**

a. Given the characteristics in Fig. 70, determine the voltage regulation of the supply.
b. Determine the internal resistance of the supply.
c. Sketch the equivalent circuit for the supply.

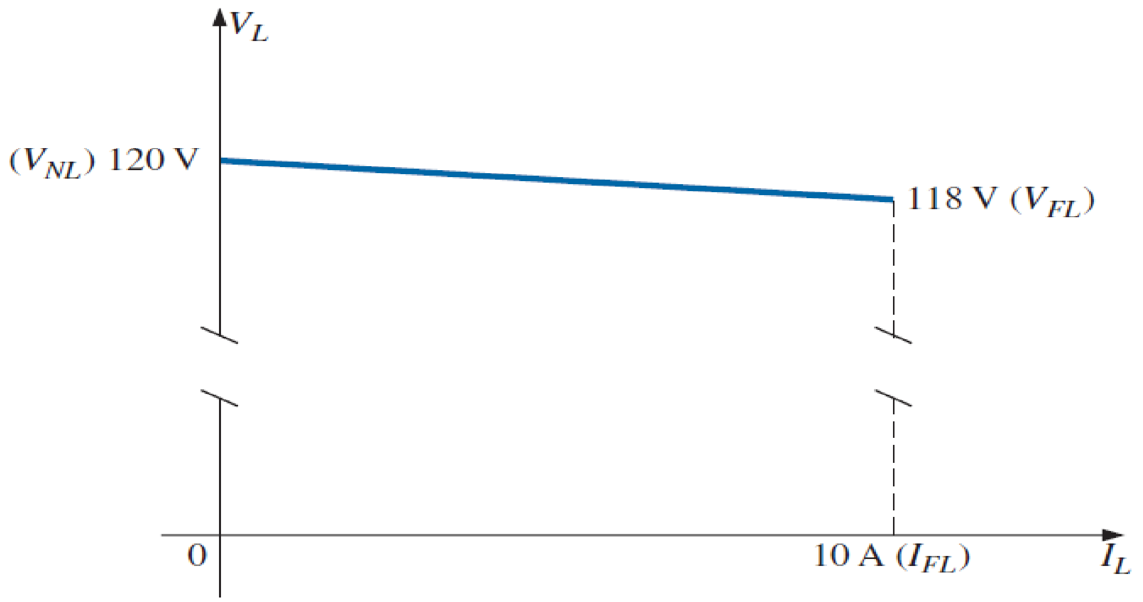



**FIG. 70**
*Terminal characteristics for the supply of Example 28.*

# VOLTAGE REGULATION AND THE INTERNAL RESISTANCE OF VOLTAGE SOURCES

**Solutions:**

a. $$VR = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\%$$

$$= \frac{120\text{ V} - 118\text{ V}}{118\text{ V}} \times 100\% = \frac{2}{118} \times 100\%$$

$$VR \cong \mathbf{1.7\%}$$

b. $$R_{\text{int}} = \frac{\Delta V_L}{\Delta I_L} = \frac{120\text{ V} - 118\text{ V}}{10\text{ A} - 0\text{ A}} = \frac{2\text{ V}}{10\text{ A}} = \mathbf{0.2\ \Omega}$$

c. See Fig. 71.

# Parallel DC Circuits

**EXAMPLE 3** Find the total resistance of the configuration in Fig. 6.

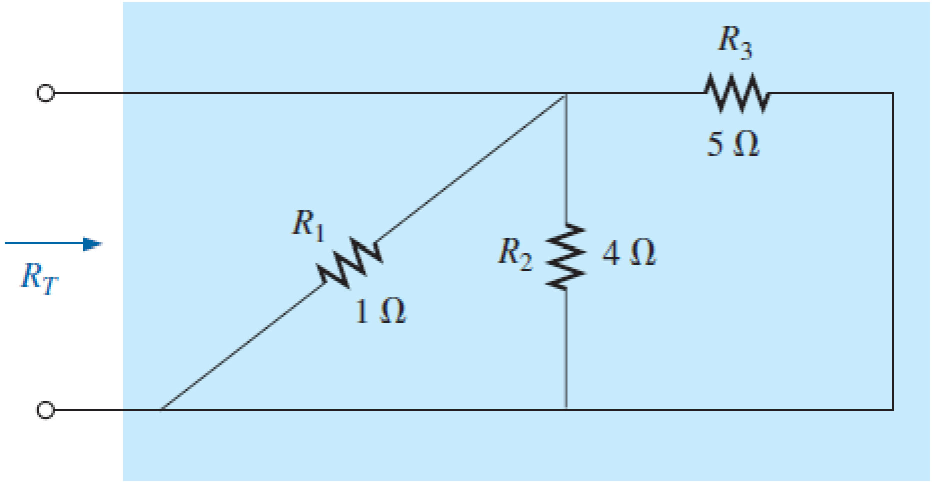



**FIG. 6**

*Network to be investigated in Example 3.*

# Parallel DC Circuits

**EXAMPLE 4**

a. What is the effect of adding another resistor of 100 Ω in parallel with the parallel resistors of Example 1 as shown in Fig. 8?
b. What is the effect of adding a parallel 1 Ω resistor to the configuration in Fig. 8?

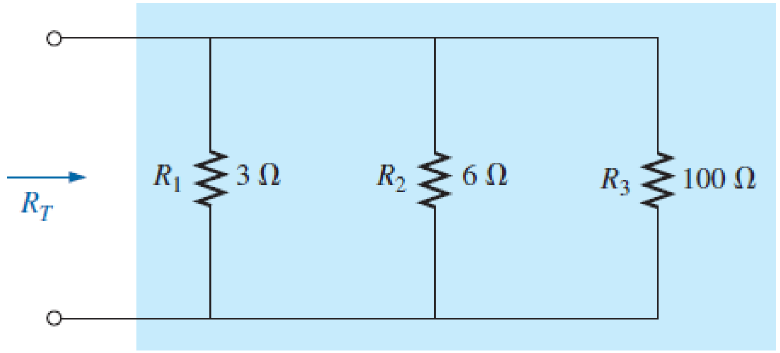



**FIG. 8**
*Adding a parallel 100 Ω resistor to the network in Fig. 4.*

# Parallel DC Circuits

**EXAMPLE 6** Find the total resistance for the configurati

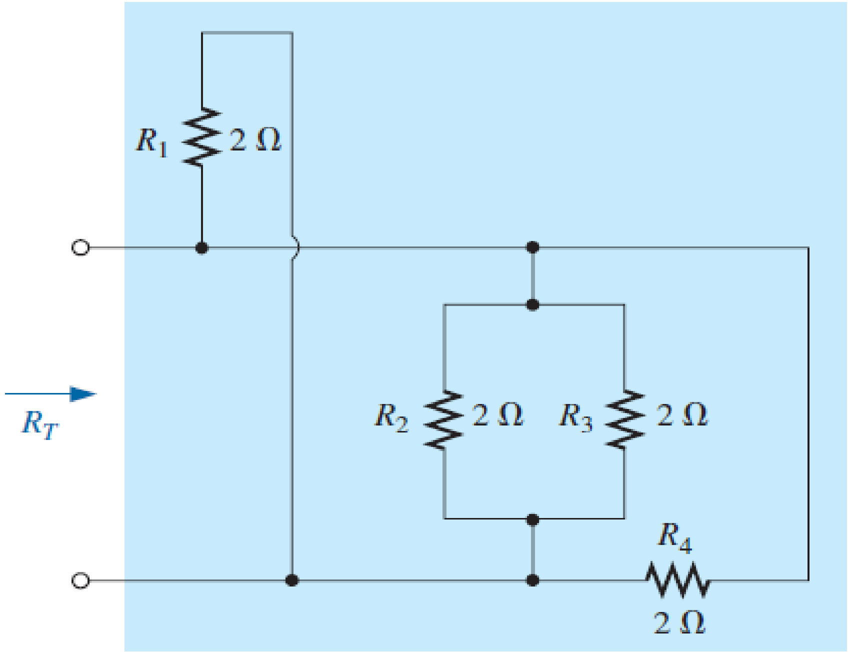



**FIG. 10**
*Parallel configuration for Example 6.*

# Parallel DC Circuits

**EXAMPLE 12** For the parallel network in Fig. 22:

a. Find the total resistance.
b. Calculate the source current.
c. Determine the current through each parallel branch.
d. Show that Eq. (9) is satisfied.

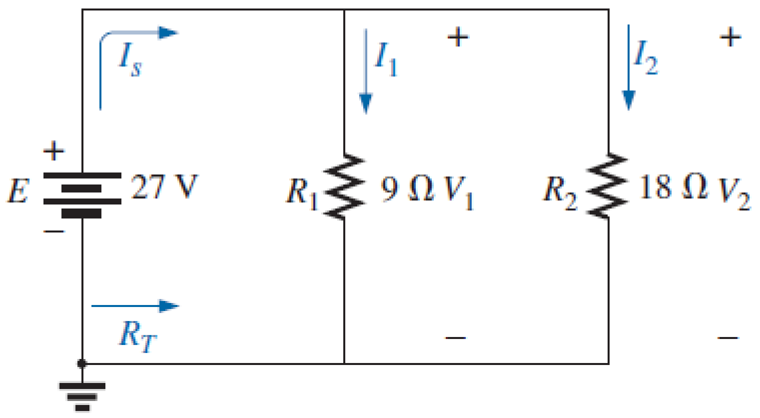



**FIG. 22**
*Parallel network for Example 12.*

# Parallel DC Circuits

**EXAMPLE 15** For the parallel network in Fig. 29 (all standard values):

a. Determine the total resistance $R_T$.
b. Find the source current and the current through each resistor.
c. Calculate the power delivered by the source.
d. Determine the power absorbed by each parallel resistor.
e. Verify Eq. (10).

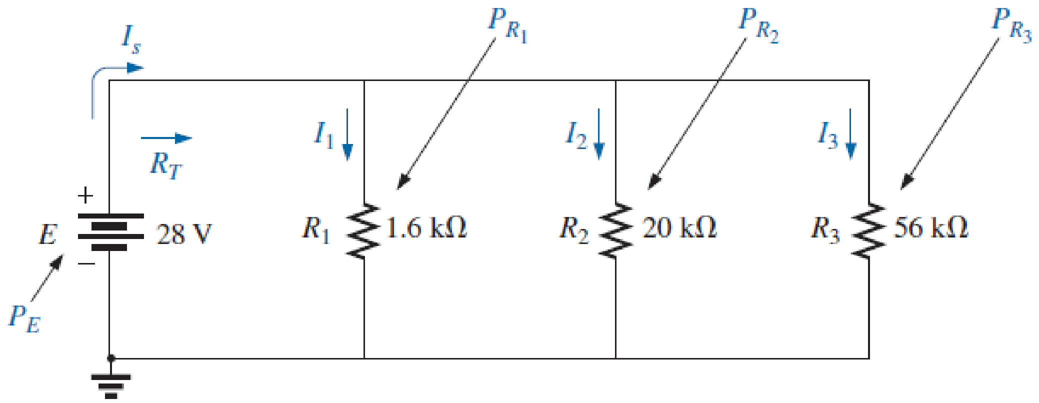
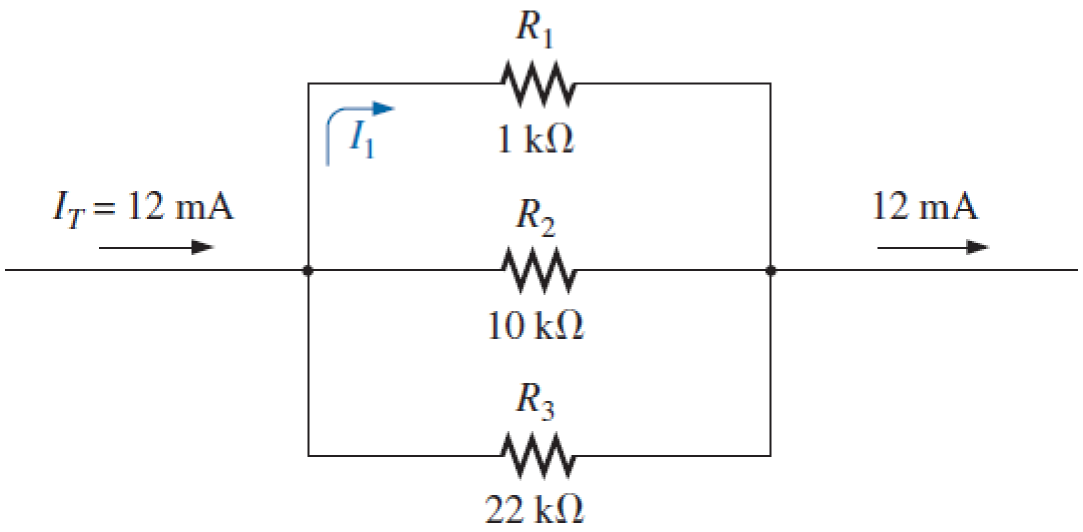



**FIG. 29**
*Parallel network for Example 15.*

# Parallel DC Circuits

**EXAMPLE 22** For the parallel network in Fig. 41, determine current $I_1$ using Eq. (14).



# VOLTAGE SOURCES IN PARALLEL

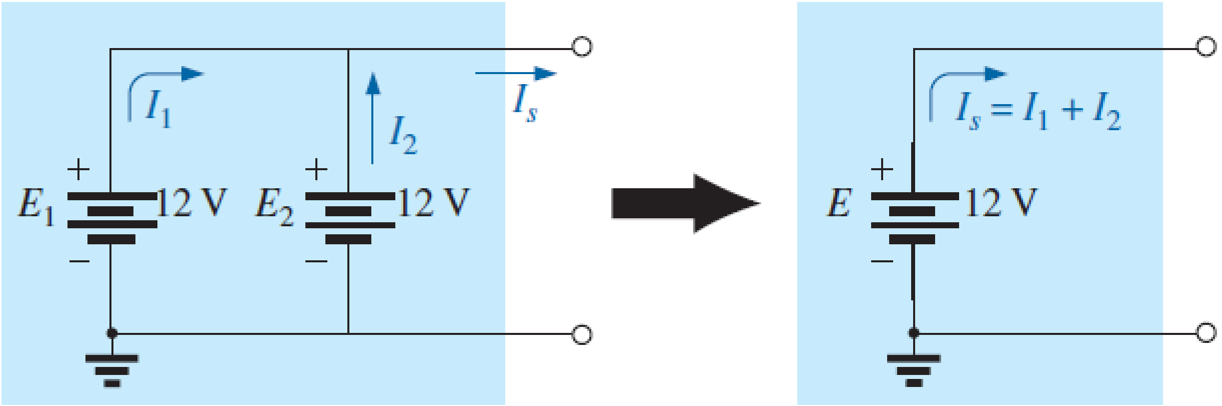



**FIG. 46**

*Demonstrating the effect of placing two ideal supplies of the same voltage in parallel.*

- Voltage sources can be placed in parallel only if they have the same voltage.
- The primary reason for placing two or more batteries or supplies in parallel is to increase the current rating above that of a single supply.

# VOLTAGE SOURCES IN PARALLEL

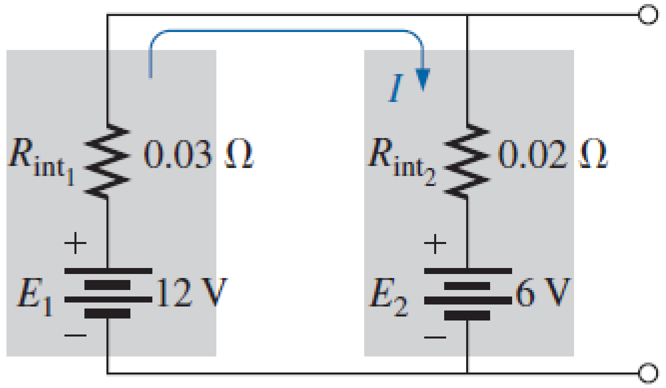



**FIG. 47**

*Examining the impact of placing two lead-acid batteries of different terminal voltages in parallel.*

$$I = \frac{E_1 - E_2}{R_{int_1} + R_{int_2}} = \frac{12\text{ V} - 6\text{ V}}{0.03\ \Omega + 0.02\ \Omega} = \frac{6\text{ V}}{0.05\ \Omega} = 120\text{ A}$$

# Open Circuit

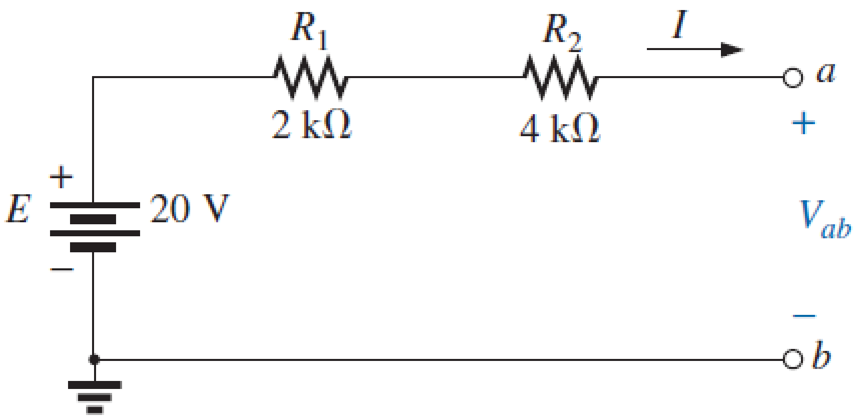



**FIG. 53**
*Network for Example 25.*

# Open Circuit

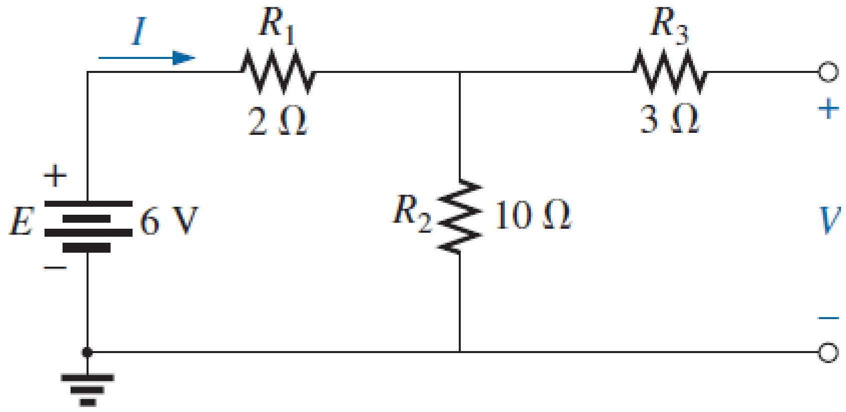



**FIG. 58**
*Network for Example 28.*

# Voltmeter loading effect

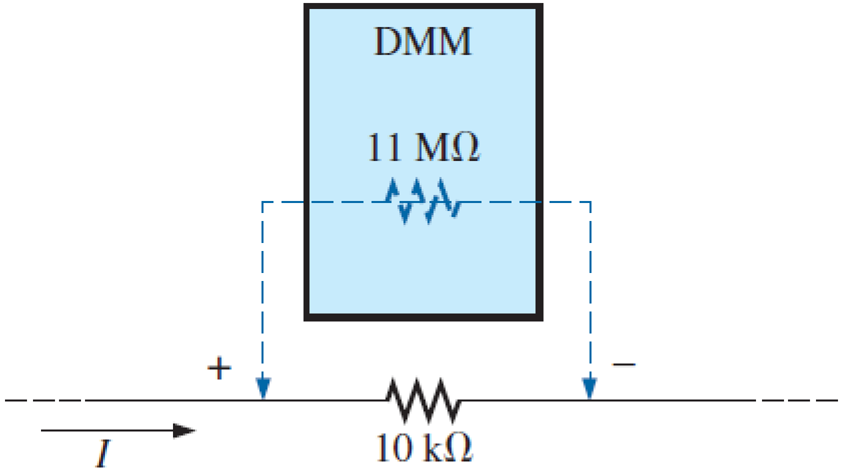



**FIG. 60**
*Voltmeter loading.*

$$R_T = 10\text{ k}\Omega \,\|\, 11\text{ M}\Omega = \frac{(10^4\,\Omega)(11 \times 10^6\,\Omega)}{10^4\,\Omega + (11 \times 10^6)} = 9.99\text{ k}\Omega$$