FID Day 4

The Pennsylvania State University
Workforce Education and Development

Lesson Plan Template

Name of Instructor: Barry Sunderland
Program Title: Electrical and Power Transmission Installers
Course Title: Electrical Occupations
Unit Title: Electrical Theory
Lesson Title: Series Circuits
Lesson Performance Objective: Students will learn the properties of a series circuit and be able to calculate the different values of a series circuit in regards to volts, amps, ohms, and watts with 80% accuracy.
Time (length of lesson): 40 minutes
Equipment and Materials needed: Chapter 5 Reading Materials Chapter Review Exercises Calculator
Technical Standard(s): NOCTI Construction Math Task 1108 Apply Ohms/Watts Law
Academic Standard(s): CC.2.1.HS.F.2 Apply properties of rational and irrational numbers … CC.2.2.HS.D.2 Write Expressions in equivalent forms to solve problems
Introduction We are going to begin looking at the construction of circuits. There are two ways that circuits can be put together, series or parallel. Today, we will focus on series circuits.

Body:

- Read through the material for Chapter 5
- Review the practice scenarios
- Complete the Chapter review questions
- Complete the Practice Problems

Summary:
Series circuits are designed so that current must flow through one component or device to get to another. This is very important for specialty systems and control wiring.

Student Assessment:

Students will complete the practice problems and compute the values of the circuits.

Universal Design for Learning (UDL)

Extended time

Use of Calculators

Individual assistance from teacher or para

CHAPTER 5

Series Circuits

OBJECTIVES

After studying this unit, you should be able to:

- discuss the properties of series circuits.
- list three rules for solving electrical values of series circuits.
- compute values of voltage, current, resistance, and power for series circuits.
- compute the values of voltage drop in a series circuit using the voltage divider formula.

Electrical circuits can be divided into three major types: series, parallel and combination. Combination circuits contain both series and parallel paths. The first type discussed is the series circuit.

SERIES CIRCUITS

A series circuit is a circuit that has only one path for current flow (Fig. 5-1). Because there is only one path for current flow, the current is the same at any point in the circuit. Imagine that an electron leaves the negative terminal of the battery. This electron must flow through each resistor before it can complete the circuit to the positive battery terminal.

One of the best examples of a series-connected device is a fuse or circuit breaker (**Fig. 5-2**). Since fuses and **circuit breakers** are connected in series

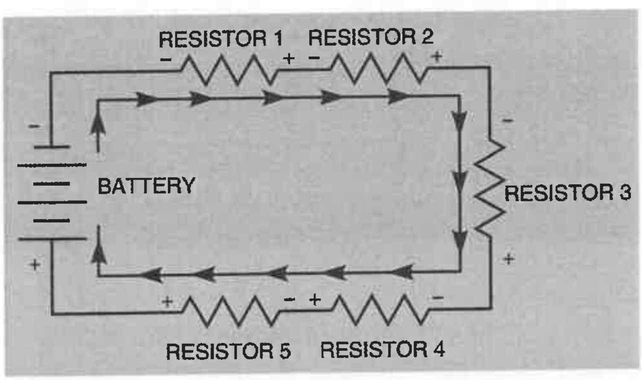

FIGURE 5-1 In a series circuit there is only one path for current flow.

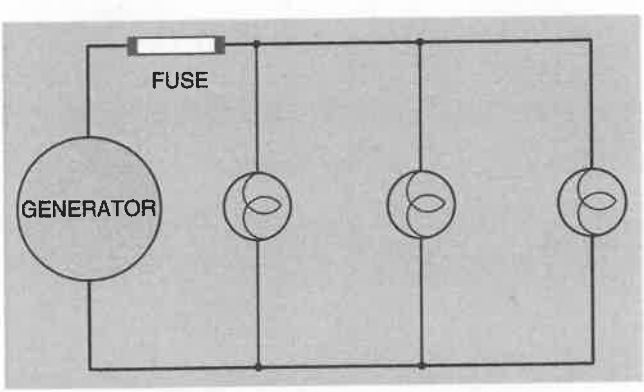

FIGURE 5-2 All the current must flow through the fuse.

with the rest of the circuit, all the circuit current must flow through them. If the current becomes excessive, the fuse or circuit breaker will open and disconnect the rest of the circuit from the power source.

VOLTAGE DROPS IN A SERIES CIRCUIT

Voltage is the force that pushes the electrons through a resistance. The amount of voltage required is determined by the amount of current flow and resistance. If a voltmeter is connected across a resistor (**Fig. 5-3**), the amount of voltage necessary to push the current through that resistor will be indicated by the meter. This amount is known as **voltage drop**. It is similar to pressure drop in a water system. **In a series circuit, the sum of all the voltage drops across all the resistors must equal the voltage applied to the circuit.** The amount of voltage drop across each resistor will be proportional to its resistance and the circuit current.

In the circuit shown in **Figure 5-4**, four resistors are connected in series. It is assumed that all four resistors have the same value. The circuit is connected to a 24-V battery. Since all the resistors have the same value, the voltage drop across each will be 6 V (24 V/4 resistors = 6 V). Note that all four resistors will have the same voltage drop only if they all have the same value. The circuit shown in **Figure 5-5** illustrates a series circuit comprising resistors of different values. Notice that the voltage drop across each resistor is proportional to its

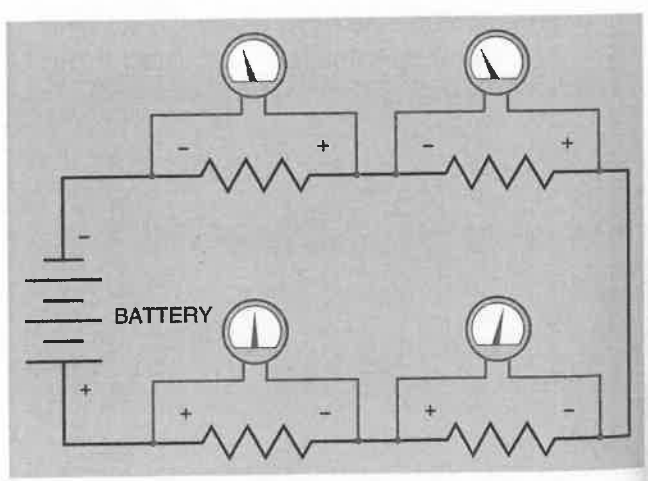

FIGURE 5-3 The voltage drops in a series circuit must equal the applied voltage.

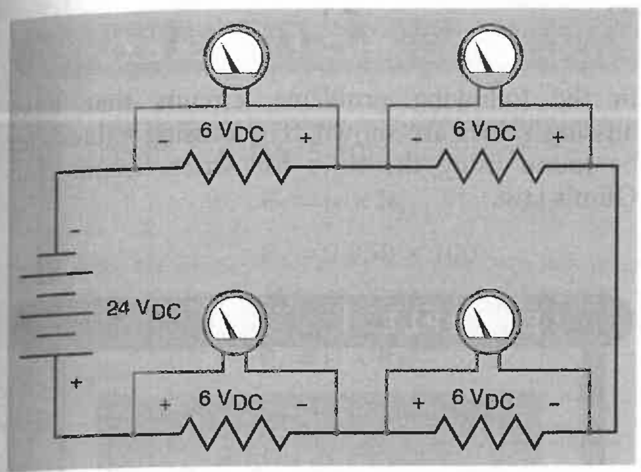

FIGURE 5-4 The voltage drop across each resistor is proportional to its resistance.

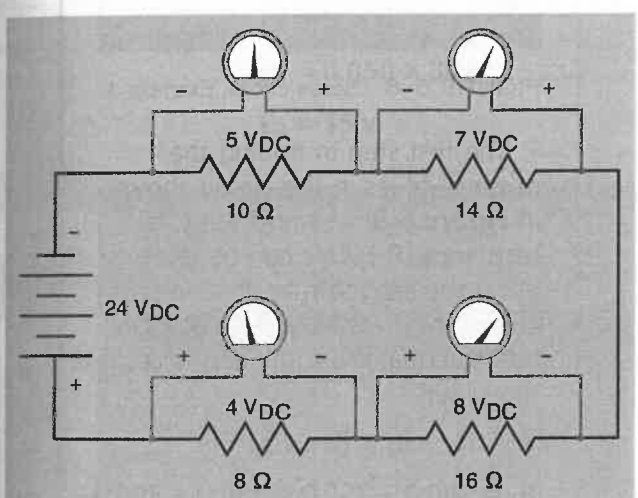

FIGURE 5-5 Series circuit with four resistors having different voltage drops.

resistance. Also notice that the sum of the voltage drops is equal to the applied voltage of 24 V.

RESISTANCE IN A SERIES CIRCUIT

Because there is only one path for the current to flow through a series circuit, it must flow through each resistor in the circuit (Fig. 5-1). Each resistor limits or impedes the flow of current in the circuit. Therefore, the total amount of series resistance to current flow in a series circuit is equal to the sum of the resistances in that circuit.

CALCULATING SERIES CIRCUIT VALUES

Three rules can be used with Ohm's law for finding values of voltage, current, resistance, and power in any series circuit.

1 The current is the same at any point in the circuit.
2 The total resistance is the sum of the individual resistors.
3 The applied voltage is equal to the sum of the voltage drops across all the resistors.

The circuit shown in **Figure 5-6** shows the values of current flow, voltage drop, and resistance for each of the resistors. The total resistance (R_T) of the circuit can be found by adding the values of the three resistors (**resistance adds**).

$$R_T = R_1 + R_2 + R_3$$
$$R_T = 20\,\Omega + 10\,\Omega + 30\,\Omega$$
$$R_T = 60\,\Omega$$

The amount of current flow in the circuit can be found using Ohm's law.

$$I = \frac{E}{R}$$
$$I = \frac{120}{60}$$
$$I = 2\,A$$

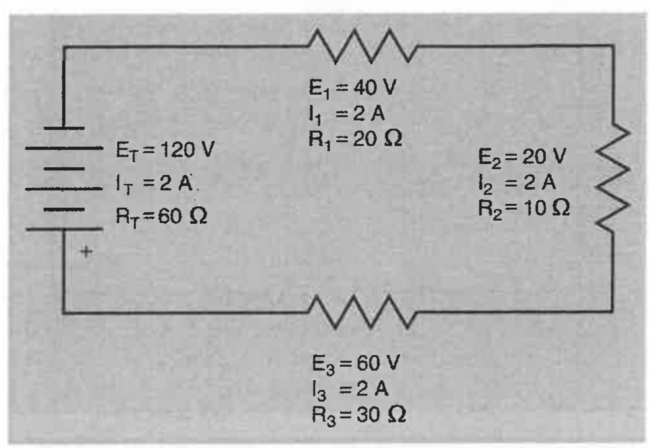

FIGURE 5-6 Series circuit values.

A current of 2 A flows through each resistor in the circuit.

$$I_T = I_1 = I_2 = I_3$$

Since the amount of current flowing through resistor R_1 is known, the voltage drop across the resistor can be found using Ohm's law.

$$E_1 = I_1 \times R_1$$
$$E_1 = 2\,A \times 20\,\Omega$$
$$E_1 = 40\,V$$

In other words, it takes 40 V to push 2 A of current through 20 Ω of resistance. If a voltmeter were connected across resistor R_1, it would indicate a value of 40 V (**Fig. 5-7**). The voltage drop across resistors R_2 and R_3 can be found in the same way.

$$E_2 = I_2 \times R_2$$
$$E_2 = 2\,A \times 10\,\Omega$$
$$E_2 = 20\,V$$
$$E_3 = I_3 \times R_3$$
$$E_3 = 2\,A \times 30\,\Omega$$
$$E_3 = 60\,V$$

If the voltage drop across all the resistors is added, it equals the total applied voltage (E_T).

$$E_T = E_1 + E_2 + E_3$$
$$E_T = 40\,V + 20\,V + 60\,V$$
$$E_T = 120\,V$$

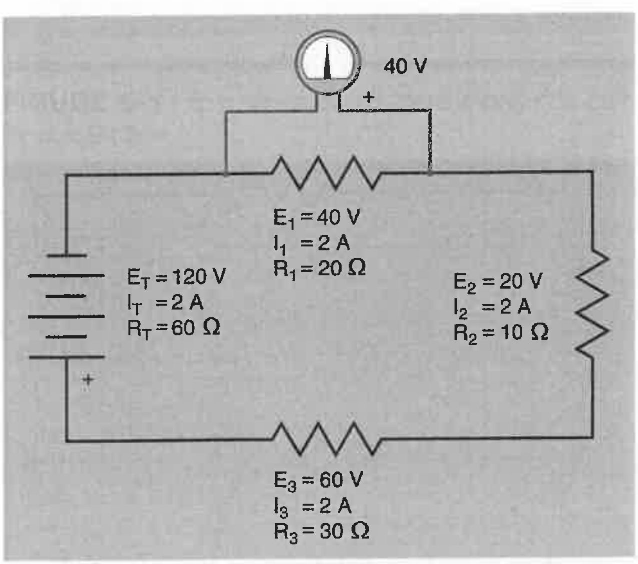

FIGURE 5-7 The voltmeter indicates a voltage drop of 40 V.

Solving Circuits

In the following problems, circuits that have missing values are shown. The missing values can be found using the rules for series circuits and Ohm's law.

EXAMPLE 1

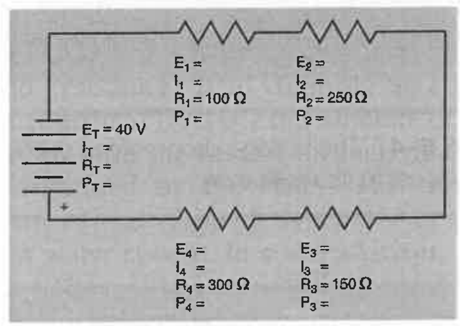

FIGURE 5-8 Series circuit, Example 1.

The first step in finding the missing values in the circuit shown in **Figure 5-8** is to find the total resistance (R_T). This can be done using the second rule of series circuits, which states that resistances add to equal the total resistance of the circuit.

$$R_T = R_1 + R_2 + R_3 + R_4$$
$$R_T = 100\,\Omega + 250\,\Omega + 150\,\Omega + 300\,\Omega$$
$$R_T = 800\,\Omega$$

Now that the total voltage and total resistance are known, the current flow through the circuit can be found using Ohm's law.

$$I = \frac{E}{R}$$
$$I = \frac{40}{800}$$
$$I = 0.050\,A$$

The first rule of series circuits states that current remains the same at any point in the circuit. Therefore, 0.050 A flows through each resistor in the circuit (**Fig. 5-9**). The voltage drop

EXAMPLE 1 CONTINUED

across each resistor can now be found using Ohm's law (**Fig. 5-10**).

$$E_1 = I_1 \times R_1$$
$$E_1 = 0.050 \times 100$$
$$E_1 = 5\,V$$
$$E_2 = I_2 \times R_2$$
$$E_2 = 0.050 \times 250$$
$$E_2 = 12.5\,V$$
$$E_3 = I_3 \times R_3$$
$$E_3 = 0.050 \times 150$$
$$E_3 = 7.5\,V$$
$$E_4 = I_4 \times R_4$$
$$E_4 = 0.050 \times 300$$
$$E_4 = 15\,V$$

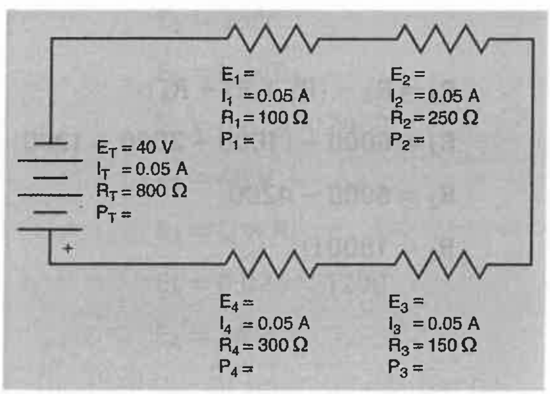

FIGURE 5-9 The current is the same at any point in a series circuit.

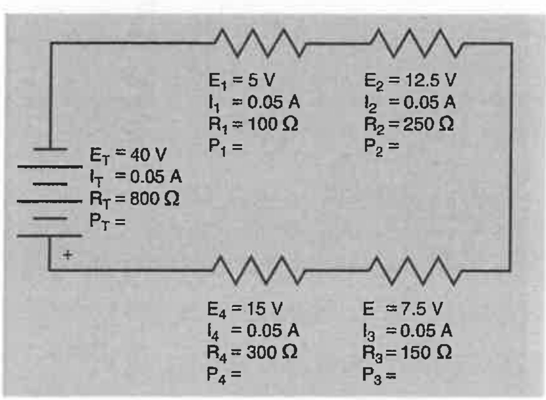

FIGURE 5-10 The voltage drop across each resistor can be found using Ohm's law.

Several formulas can be used to determine the amount of power dissipated (converted into heat) by each resistor. The power dissipation of resistor R_1 will be found using the formula

$$P_1 = E_1 \times I_1$$
$$P_1 = 5 \times 0.05$$
$$P_1 = 0.25\,W$$

The amount of power dissipation for resistor R_2 will be computed using the formula

$$P_2 = \frac{E_2^2}{R_2}$$
$$P_2 = \frac{156.25}{250}$$
$$P_2 = 0.625\,W$$

The amount of power dissipation for resistor R_3 will be computed using the formula

$$P_3 = I_3^2 \times R_3$$
$$P_3 = 0.0025 \times 150$$
$$P_3 = 0.375\,W$$

The amount of power dissipation for resistor R_4 will be found using the formula

$$P_4 = E_4 \times I_4$$
$$P_4 = 15 \times 0.05$$
$$P_4 = 0.75\,W$$

A good rule to remember when calculating values of electrical circuits is that **the total power used in a circuit is equal to the sum of the power used by all parts.** That is, the total power can be found in any kind of a circuit—series, parallel, or combination—by adding the power dissipation of all the parts. The total power for this circuit can be found using the formula

$$P_T = P_1 + P_2 + P_3 + P_4$$
$$P_T = 0.25 + 0.625 + 0.375 + 0.75$$
$$P_T = 2\,W$$

Now that all the missing values have been found (**Fig. 5-11**), the circuit can be checked using the third rule of series circuits, which

EXAMPLE 1 CONTINUED

states that voltage drops add to equal the applied voltage.

$$E_T = E_1 + E_2 + E_3 + E_4$$

$$E_T = 5 + 12.5 + 7.5 + 15$$

$$E_T = 40\,V$$

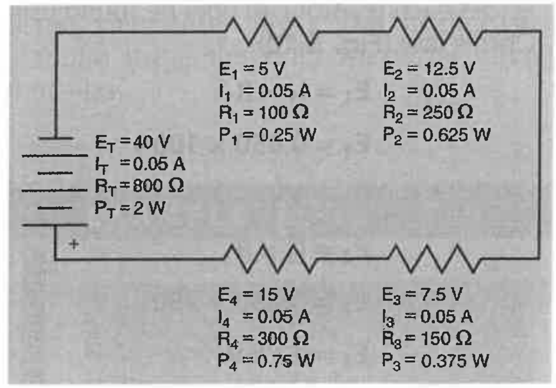

FIGURE 5-11 The final values for the circuit in Example 1.

EXAMPLE 2

The second circuit to be solved is shown in **Figure 5-12**. In this circuit the total resistance is known, but the value of resistor R_2 is not. The second rule of series circuits states that resistances add to equal the total resistance of the circuit. Since the total resistance is known, the missing resistance of R_2 can be found by adding the values of the other resistors and subtracting their sum from the total resistance of the circuit (**Fig. 5-13**).

$$R_2 = R_T - (R_1 + R_3 + R_4)$$

$$R_2 = 6000 - (1000 + 2000 + 1200)$$

$$R_2 = 6000 - 4200$$

$$R_2 = 1800\,\Omega$$

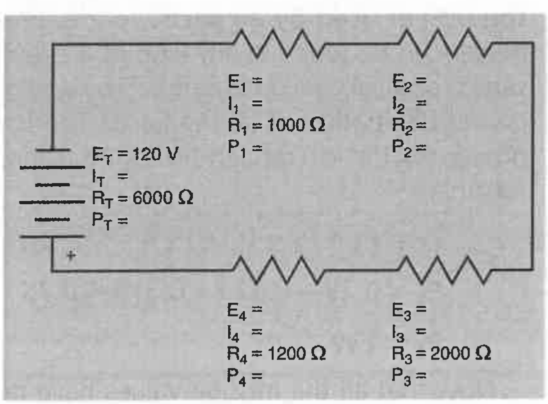

FIGURE 5-12 Series circuit, Example 2.

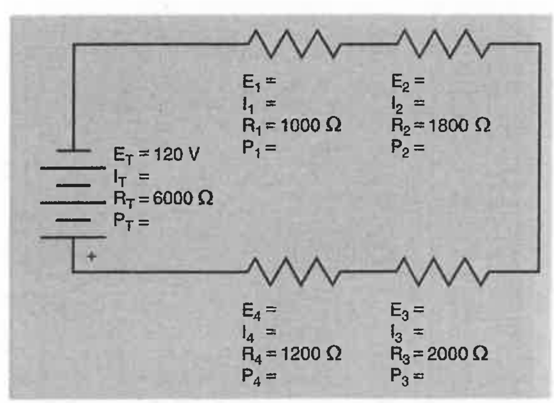

FIGURE 5-13 The missing resistor value.

EXAMPLE 2 CONTINUED

The amount of current flow in the circuit can be found using Ohm's law.

$$I = \frac{E}{R}$$

$$I = \frac{120}{6000}$$

$$I = 0.020\ A$$

Since the amount of current flow is the same through all elements of a series circuit (**Fig. 5-14**), the voltage drop acros each resistor can be found using Ohm's law (**Fig. 5-15**).

$$E_1 = I_1 \times R_1$$

$$E_1 = 0.020 \times 1000$$

$$E_1 = 20\ V$$

$$E_2 = I_2 \times R_2$$

$$E_2 = 0.020 \times 1800$$

$$E_2 = 36\ V$$

$$E_3 = I_3 \times R_3$$

$$E_3 = 0.020 \times 2000$$

$$E_3 = 40\ V$$

$$E_4 = I_4 \times R_4$$

$$E_4 = 0.020 \times 1200$$

$$E_4 = 24\ V$$

The third rule of series circuits can be used to check the answers.

$$E_T = E_1 + E_2 + E_3 + E_4$$

$$E_T = 20 + 36 + 40 + 24$$

$$E_T = 120\ V$$

The amount of power dissipation for each resistor in the circuit can be computed using the same method used to solve the circuit in Example 1. The power dissipated by resistor R_1 will be computed using the formula

$$P_1 = E_1 \times I_1$$

$$P_1 = 20 \times 0.02$$

$$P_1 = 0.4 W$$

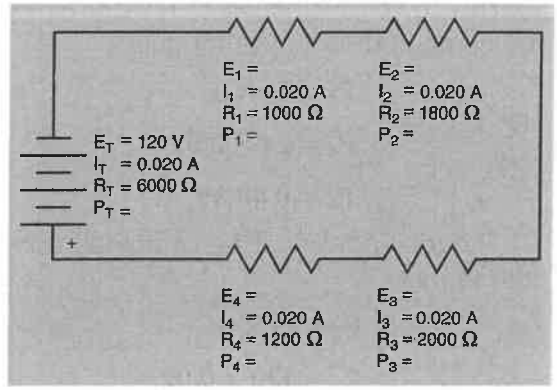

FIGURE 5-14 The current is the same through each circuit element.

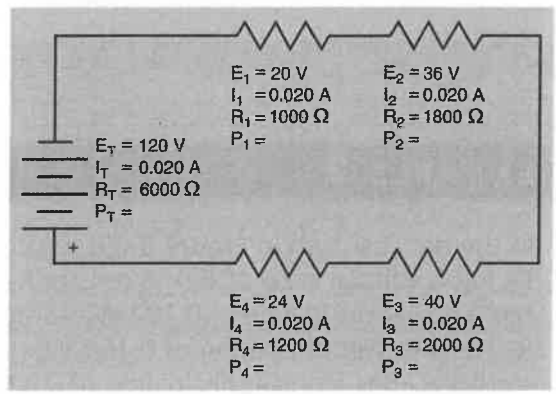

FIGURE 5-15 The voltage drops across each resistor.

The amount of power dissipation for resistor R_2 will be found using the formula

$$P_2 = \frac{E_2^2}{R_2}$$

$$P_2 = \frac{1296}{1800}$$

$$P_2 = 0.72\ W$$

The power dissipation of resistor R_3 will be found using the formula

$$P_3 = I_3^2 \times R_3$$

$$P_3 = 0.0004 \times 2000$$

$$P_3 = 0.8\ W$$

EXAMPLE 2 CONTINUED

The power dissipation of resistor R_4 will be computed using the formula

$$P_4 = E_4 \times I_4$$

$$P_4 = 24 \times 0.02$$

$$P_4 = 0.48 \text{ W}$$

The total power will be computed using the formula

$$P_T = E_T \times I_T$$

$$P_T = 120 \times 0.02$$

$$P_T = 2.4 \text{ W}$$

The circuit, with all computed values, is shown in **Figure 5-16**.

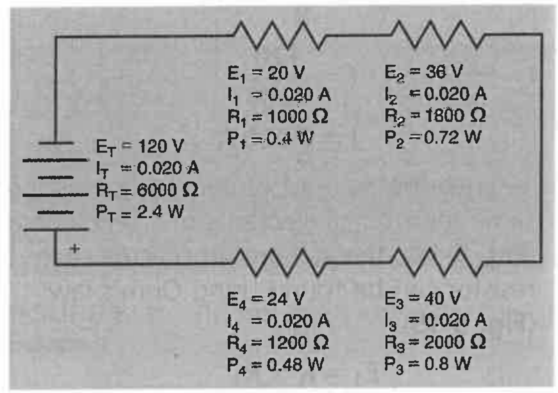

FIGURE 5-16 The remaining unknown values for the circuit in Example 2.

EXAMPLE 3

In the circuit shown in **Figure 5-17**, resistor R_1 has a voltage drop of 6.4 V, resistor R_2 has a power dissipation of 0.102 W, resistor R_3 has a power dissipation of 0.154 W, resistor R_4 has a power dissipation of 0.307 W, and the total power consumed by the circuit is 0.768 W.

The only value that can be found with the given quantities is the amount of power dissipated by resistor R_1. Since the total power is known and the power dissipated by the three other resistors is known, the power dissipated by resistor R_1 can be found by subtracting the power dissipated by resistors R_2, R_3, and R_4 from the total power used in the circuit.

$$P_1 = P_T - (P_2 + P_3 + P_4)$$

or

$$P_1 = P_T - P_2 - P_3 - P4$$

$$P_1 = 0.768 - 0.102 - 0.154 - 0.307$$

$$P_1 = 0.205\text{W}$$

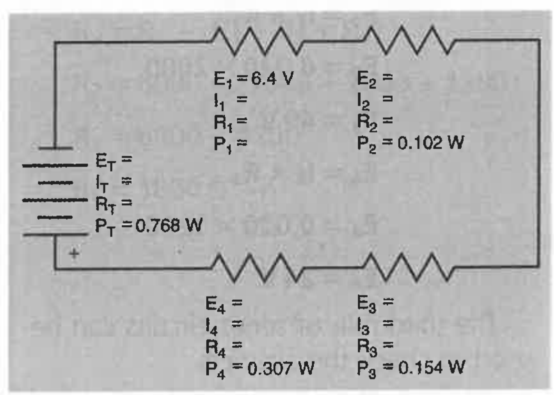

FIGURE 5-17 Series circuit, Example 3.

Now that the amount of power dissipated by resistor R_1 and the voltage drop across R_1 are known, the current flow through resistor R_1 can be found using the formula

$$I = \frac{P}{E}$$

$$I = \frac{0.205}{6.4}$$

$$I = 0.032 \text{ A}$$

Since the current in a series circuit must be the same at any point in the circuit, it must be

EXAMPLE 3 CONTINUED

the same through all circuit components (**Fig. 5-18**).

Now that the power dissipation of each resistor and the amount of current flowing through each resistor are known, the voltage drop of each resistor can be computed (**Fig. 5-19**).

$$E_2 = \frac{P_2}{I_2}$$

$$E_2 = \frac{0.102}{0.032}$$

$$E_2 = 3.2\,V$$

$$E_3 = \frac{P_3}{I_3}$$

$$E_3 = \frac{0.154}{0.032}$$

$$E_3 = 4.8\,V$$

$$E_4 = \frac{P_4}{I_4}$$

$$E_4 = \frac{0.307}{0.032}$$

$$E_4 = 9.6\,V$$

Ohm's law can now be used to find the Ohmic value of each resistor in the circuit (**Fig. 5-20**).

$$R_1 = \frac{E_1}{I_1}$$

$$R_1 = \frac{6.4}{0.032}$$

$$R_1 = 200\,\Omega$$

$$R_2 = \frac{E_2}{I_2}$$

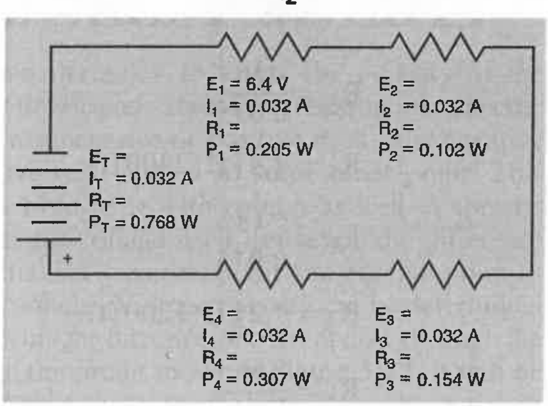

FIGURE 5-18 The current flow in the circuit in Example 3.

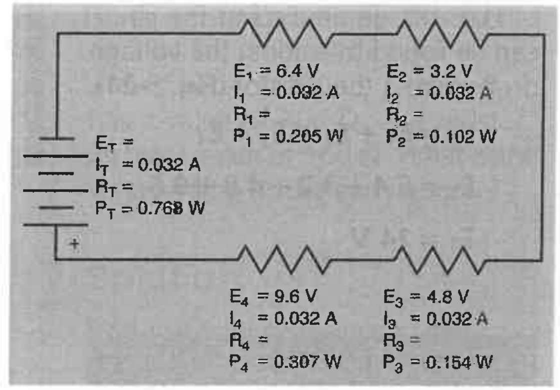

FIGURE 5-19 The voltage drops across each resistor.

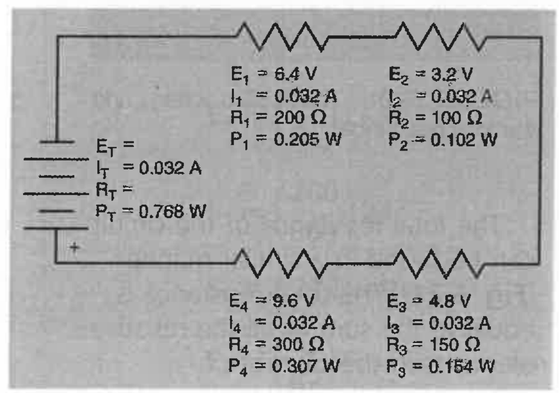

FIGURE 5-20 The Ohmic value of each resistor.

$$R_2 = \frac{3.2}{0.032}$$

$$R_2 = 100\,\Omega$$

$$R_3 = \frac{E_3}{I_3}$$

$$R_3 = \frac{4.8}{0.032}$$

$$R_3 = 150\,\Omega$$

$$R_4 = \frac{E_4}{I_4}$$

$$R_4 = \frac{9.6}{0.032}$$

$$R_4 = 300\,\Omega$$

EXAMPLE 3 CONTINUED

The voltage applied to the circuit can be found by adding the voltage drops across the resistor (**Fig. 5-21**).

$$E_T = E_1 + E_2 + E_3 + E_4$$

$$E_T = 6.4 + 3.2 + 4.8 + 9.6$$

$$E_T = 24\ \text{V}$$

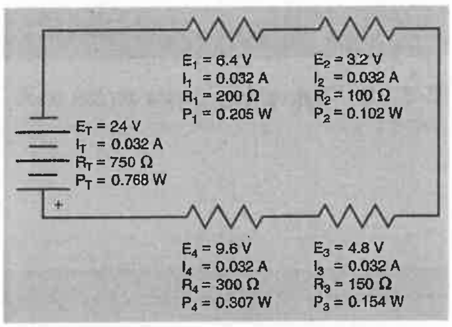

FIGURE 5-21 The applied voltage and the total resistance.

The total resistance of the circuit can be found in a similar manner (**Fig. 5-21**). The total resistance is equal to the sum of all the resistive elements in the circuit.

$$R_T = R_1 + R_2 + R_3 + R_4$$

$$R_T = 200 + 100 + 150 + 300$$

$$R_T = 750\ \Omega$$

VOLTAGE DIVIDERS

One common use for series circuits is constructing voltage dividers. A **voltage divider** works on the principle that the sum of the voltage drops across a series circuit must equal the applied voltage. Voltage dividers are used to provide different voltages between certain points (**Fig. 5-22**). If a voltmeter is connected between points A and B, a voltage of 20 V will be seen. If the voltmeter is connected between points B and D, a voltage of 80 V will be seen.

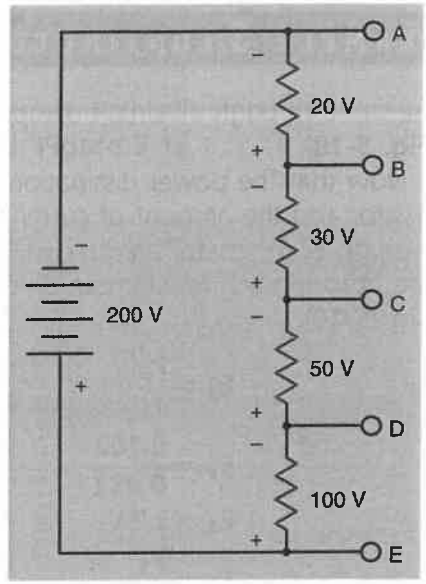

FIGURE 5-22 Series circuit used as a voltage divider.

Voltage dividers can be constructed to produce any voltage desired. For example, assume that a voltage divider is connected to a source of 120 V and is to provide voltage drops of 36 V, 18 V, and 66 V. Notice that the sum of the voltage drops equals the applied voltage. The next step is to decide how much current is to flow through the circuit. Because there is only one path for current flow, the current will be the same through all the resistors. In this circuit, a current flow of 15 mA (0.015 A) will be used. The resistance value of each resistor can now be determined.

$$R = \frac{E}{I}$$

$$R_1 = \frac{36}{0.015}$$

$$R_1 = 2.4\ \text{k}\Omega\ (2400\ \Omega)$$

$$R_2 = \frac{18}{0.015}$$

$$R_2 = 1.2\ \text{k}\Omega\ (1200\ \Omega)$$

$$R_3 = \frac{66}{0.015}$$

$$R_3 = 4.4\ \text{k}\Omega\ (4400\ \Omega)$$

The General Voltage Divider Formula

Another method of determining the voltage drop across series elements is the **general voltage divider formula.** Since the current flow through a series circuit is the same at all points in the circuit, the voltage drop across any particular resistance is equal to the total circuit current times the value of that resistor.

$$E_X = I_T \times R_X$$

The total circuit current is proportional to the source voltage (E_T) and the total resistance of the circuit.

$$I_T = \frac{E_T}{R_T}$$

If the value of I_T is substituted for E_T/R_T in the previous formula, the expression now becomes

$$E_X = \left(\frac{E_T}{R_T}\right) R_X$$

If the formula is rearranged, it becomes what is known as the general voltage divider formula.

$$E_X = \left(\frac{R_X}{R_T}\right) E_T$$

The voltage drop across any series component (E_X) can be computed by substituting the value of R_X for the resistance value of that component when the source voltage and total resistance are known.

EXAMPLE 4

Three resistors are connected in series to a 24 volt source. Resistor R_1 has a resistance of 200 Ω, resistor R_2 has a value of 300 Ω, and resistor R_3 has a value of 160 Ω. What is the voltage drop across each resistor?

Solution

Find the total resistance of the circuit.

$$R_T = R_1 + R_2 + R_3$$

$$R_T = 200 + 300 + 160$$

$$R_T = 660\ \Omega$$

Now use the voltage divider formula to compute the voltage drop across each resistor.

$$E_1 = \left(\frac{R_1}{R_T}\right) E_T$$

$$E_1 = \left(\frac{200}{660}\right) 24$$

$$E_1 = 7.273 \text{ volts}$$

$$E_2 = \left(\frac{R_2}{R_T}\right) E_T$$

$$E_2 = \left(\frac{300}{660}\right) 24$$

$$E_2 = 10.91 \text{ volts}$$

$$E_3 = \left(\frac{R_3}{R_T}\right) E_T$$

$$E_3 = \left(\frac{160}{660}\right) 24$$

$$E_3 = 5.818 \text{ volts}$$

Voltage Polarity

It is often necessary to know the polarity of the voltage developed across a resistor. A specific point is not negative or positive itself, it is negative or positive with respect to some other point. This principle holds true with voltage as well. A specific point has no voltage itself, however, the difference of potential between that point and another point, is in fact a voltage. **Voltage polarity** can be determined by observing the direction of current flow through the circuit. In the circuit shown in **Figure 5-22**, it will be assumed that the current flows from the negative terminal of the battery to the positive terminal. Point A is connected to the negative battery terminal, and point E is connected to the positive terminal. If a voltmeter is connected across terminals A and B, terminal B will be positive with respect to A. If a voltmeter is connected across terminals B and C, however, terminal B will be negative with respect to terminal C. Notice that terminal B is closer to the negative terminal of the battery than terminal C is. Consequently, electrons flow through the resistor in a direction that makes terminal B more negative than C. Terminal C would be negative with respect to terminal D for the same reason.

USING GROUND AS A REFERENCE

Two symbols are used to represent ground (Fig. 5-23). The symbol shown in **Figure 5-23** (A) is an **earth ground** symbol. It symbolizes a **ground point** that is made by physically driving an object

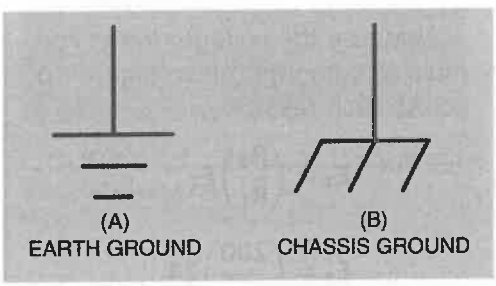

FIGURE 5-23 Ground symbols.

such as a rod or a pipe into the ground. The symbol shown in **Figure 5-23** (B) symbolizes a **chassis ground.** This point is used as a common connection for other parts of a circuit, but it is not actually driven into the ground. Although the symbol shown in **Figure 5-23** (B) is the accepted symbol for a chassis ground, the symbol shown in **Figure 5-23** (A) is often used to represent a chassis ground also.

An excellent example of using a chassis ground as a common connection can be found in the electrical system of an automobile. The negative terminal of the battery is grounded to the frame or chassis of the vehicle. The frame of the automobile is not connected directly to earth ground; it is insulated from the ground by rubber tires. In the case of an automobile electrical system, the chassis of the vehicle is the negative side of the circuit. An electrical circuit using ground as a common connection point is shown in **Figure 5-24.** This circuit is an electronic burglar alarm. Notice the numerous ground points in the schematic. In practice, when the circuit is connected, all the ground points will be connected together.

In voltage divider circuits, ground is often used to provide a common reference point to produce voltages that are above and below ground (**Fig. 5-25**). An above ground voltage is positive with respect to ground. A below ground voltage is negative with respect to ground. In **Figure 5-25**, one terminal of a zero-center voltmeter is connected to ground. If the

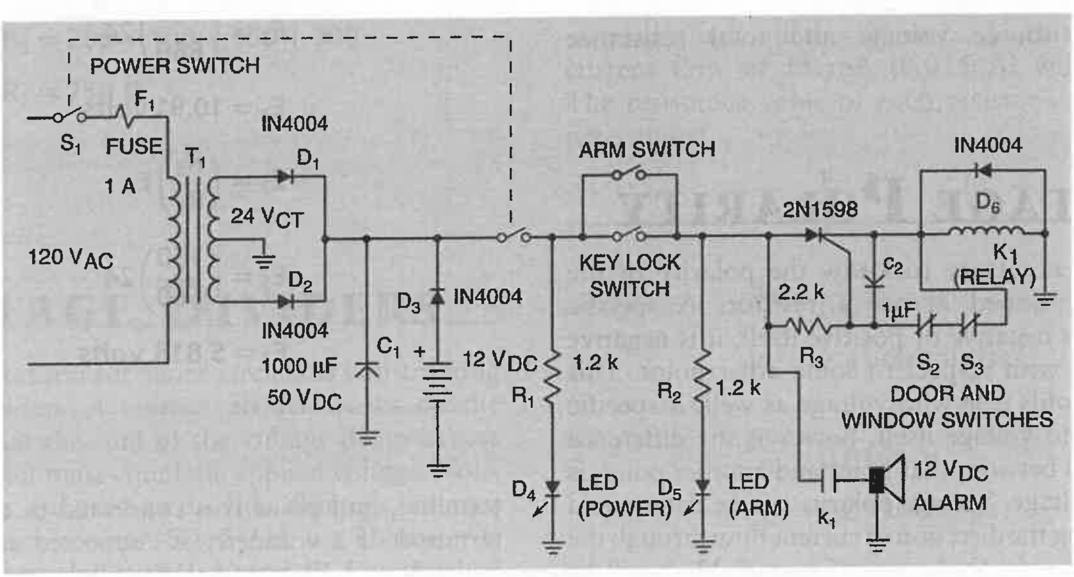

FIGURE 5-24 Burglar alarm with battery back-up.

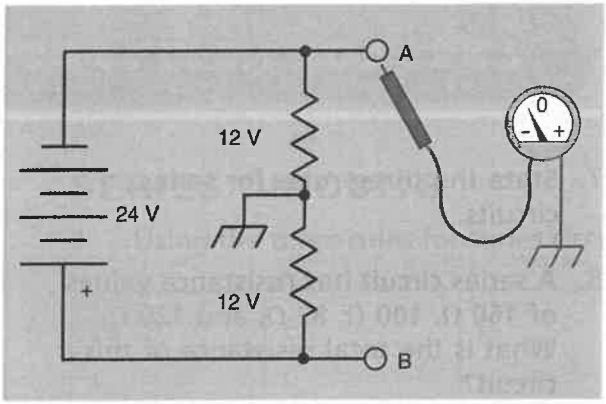

FIGURE 5-25 A common ground used to produce above and below ground voltage.

probe is connected to point A, the pointer of the voltmeter will give a negative indication for voltage. If the probe is connected to point B, the pointer will indicate a positive voltage.

SUMMARY

- Series circuits have only one path for current flow.
- The individual voltage drops in a series circuit can be added to equal the applied voltage.
- The current is the same at any point in a series circuit.
- The individual resistors can be added to equal the total resistance of the circuit.
- Fuses and circuit breakers are connected in series with the devices they are intended to protect.
- The total power in any circuit is equal to the sum of the power dissipated by all parts of the circuit.
- When the source voltage and total resistance are known, the voltage drop across each element can be computed using the general voltage divider formula.

REVIEW QUESTIONS

1. **A series circuit has individual resistor values of 200 Ω, 86 Ω, 91 Ω, 180 Ω, and 150 Ω. What is the total resistance of the circuit?**

2. **A series circuit contains four resistors. The total resistance of the circuit is 360 Ω. Three of the resistors have values of 56 Ω, 110 Ω, and 75 Ω. What is the value of the fourth resistor?**

3. **A series circuit contains five resistors. The total voltage applied to the circuit is 120 V. Four resistors have voltage drops of 35 V, 28 V, 22 V, and 15 V. What is the voltage drop of the fifth resistor?**

4. **A circuit has three resistors connected in series. Resistor R_2 has a resistance of 220 Ω and a voltage drop of 44 V. What is the current flow through resistor R_3?**

5. **A circuit has four resistors connected in series. If each resistor has a voltage drop of 60 V, what is the voltage applied to the circuit?**

6. **Define series circuit.**

7. **State the three rules for series circuits.**

8. **A series circuit has resistance values of 160 Ω, 100 Ω, 82 Ω, and 120 Ω. What is the total resistance of this circuit?**

9. **If a voltage of 24 V is applied to the circuit in question 8, what will be the total amount of current flow in the circuit?**

10. **What will be the voltage drop across each of the resistors?**

    160 Ω, ___V
    100 Ω, ___V
    82 Ω, ___V
    120 Ω, ___V

11. **A series circuit contains the following values of resistors: $R_1 = 510\ \Omega$; $R_2 = 680\ \Omega$; $R_3 = 390\ \Omega$; and $R_4 = 750\ \Omega$. Assume a source voltage of 48 V. Use the general voltage divider formula to compute the voltage drop across each of the resistors.**

    E_1=________ V E_2=________ V
    E_3=________ V E_4=________ V

PRACTICE PROBLEMS

SERIES CIRCUITS

1. Using the three rules for series circuits and Ohm's law, solve for the missing values.

E_T 120	E_1	E_2	E_3	E_4	E_5
I_T	I_1	I_2	I_3	I_4	I_5
R_T	R_1 430 Ω	R_2 360 Ω	R_3 750 Ω	R_4 1000 Ω	R_5 620 Ω
P_T	P_1	P_2	P_3	P_4	P_5

E_T	E_1	E_2	E_3 11	E_4	E_5
I_T	I_1	I_2	I_3	I_4	I_5
R_T	R_1	R_2	R_3	R_4	R_5
P_T 0.25	P_1 0.03	P_2 0.0825	P_3	P_4 0.045	P_5 0.0375

E_T 340	E_1 44	E_2 94	E_3 60	E_4 40	E_5
I_T	I_1	I_2	I_3	I_4	I_5
R_T	R_1	R_2	R_3	R_4	R_5
P_T	P_1	P_2	P_3	P_4	P_5 0.204

2. Use the general voltage divider formula to compute the values of voltage drop for the following series connected resistors. Assume a source voltage of 120 V.

$R_1 = 1K\ \Omega$; $R_2 = 2.2K\ \Omega$; $R_3 = 1.8K\ \Omega$; $R_4 = 1.5K\ \Omega$

$E_1 =$ ____ V $E_2 =$ ____ V $E_3 =$ ____ V $E_4 =$ ____ V

PRACTICAL APPLICATIONS

1. A 12-VDC automobile head lamp is to be used on a fishing boat with a 24-V system. The head lamp is rated at 50 watts. A resistor is to be connected in series with the lamp to permit it to operate on the 24-V system. What value of resistance should be used, and what is the minimum power rating of the resistor?

2. Three wire wound resistors have the following value: 30 Ω, 80 Ω, and 100 Ω. Each resistor has a voltage rating of 100 V. If these resistors are connected in series, can they be connected to a 240-V circuit without damage to the resistors? Explain your answer.

3. You are an electrician working in an industrial plant. A circuit contains eight incandescent lamps connected in series across 480 V. One lamp has burned out, and you must determine which lamp is defective. You have available a voltmeter, an ammeter, and an ohmmeter. Which meter would you use to determine the defective lamp in the shortest possible time? Explain how you would use this meter and why.