FID Day 5

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: Parallel Circuits
Lesson Performance Objective: Students will learn the properties of a parallel 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 6 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 continue looking at the construction of circuits. There are two ways that circuits can be put together, series or parallel. Today, we will focus on parallel circuits.

Body: • Read through the material for Chapter 6 • Review the practice scenarios • Complete the Chapter review questions • Complete the Practice Problems
Summary: Parallel circuits are designed so that current must flow around one component or device to get to another. This is very common in most residential wiring applications.
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 6

Parallel Circuits

OBJECTIVES *After studying this unit, you should be able to:*

- discuss the characteristics of parallel circuits.
- state three rules for solving electrical values of parallel circuits.
- solve the missing values in a parallel circuit using the three rules and Ohm's law.
- discuss the operation of a current divider circuit.
- calculate current values using the current divider formula.

GLOSSARY OF PARALLEL CIRCUIT TERMS

circuit branch (a) in the case of parallel circuits, a circuit derived from a main set of circuit conductors that supply power to multiple other circuits; (b) normally the circuit that supplies power to electrical equipment from the last protective device, such as a fuse or circuit breaker

current adds one of the three rules used to solve values of voltage, current, resistance, and power in a parallel circuit

current divider formula a formula used to calculate the amount of current flow in any branch when the total circuit current and resistance are known

load the amount of power a circuit is supplying to a device

parallel circuits circuits with more than one path for current flow

product over sum formula

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

one of three formulas used to determine the total resistance of resistors connected in parallel

reciprocal formula

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

one of three formulas used to determine the total resistance of resistors connected in parallel

Parallel circuits are probably the type of circuit with which most people are familiar. Most devices such as lights and receptacles in homes and office buildings are connected in parallel. Imagine if the lights in your home were wired in series. All the lights in the home would have to be turned on in order for any light to operate, and if one were to burn out, all the lights would go out. The same is true for receptacles. If receptacles were connected in series, some device would have to be connected into each receptacle before power could be supplied to any other device.

PARALLEL CIRCUIT VALUES

TOTAL CURRENT

Parallel circuits are circuits that have more than one path for current flow (**Fig. 6-1**). If it is assumed that current leaves terminal A and returns to terminal B, it can be seen that the electrons can take three separate paths. In **Figure 6-1**, 3 A of current leave terminal A. One amp flows through resistor R_1 and 2 A flow to resistors R_2 and R_3. At the junction of resistors R_2 and R_3, 1 A flows through resistor R_2, and 1 A flows to resistor R_3. Notice that the power supply, terminals A and B, must furnish all the current that flows through each individual resistor, or **circuit branch.** One of the rules for parallel circuits states that **the total current flow in the circuit is equal to the sum of the currents through all of the branches; this is known as current adds.** ($I_{TOTAL} = I_1 + I_2 + \ldots I_n$) Notice that the amount of current leaving the source **must** return to the source.

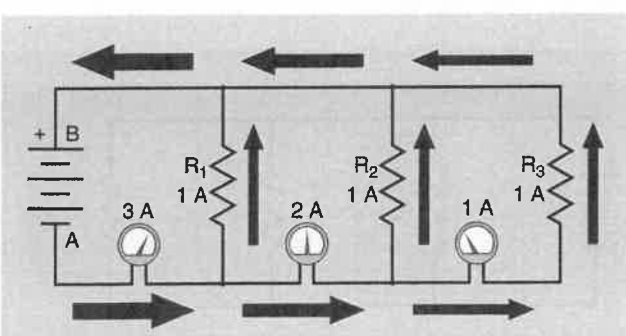

FIGURE 6-1 Parallel circuits provide more than one path for current flow.

VOLTAGE DROP

Figure 6-2 shows another parallel circuit and gives the values of voltage, current, and resistance for each individual resistor or branch. Notice that the voltage drop across all three resistors is the same. If the circuit is traced, it can be seen that each resistor is connected directly to the power source. A second rule for parallel circuits states that **the voltage drop across any branch of a parallel circuit is the same as the applied voltage.**

For this reason, most electrical circuits in homes are connected in parallel. Each lamp and receptacle is supplied with 120 V (**Fig. 6-3**).

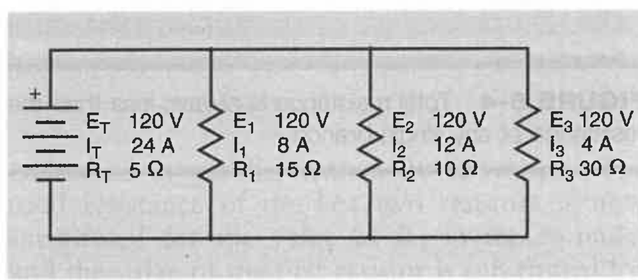

FIGURE 6-2 Parallel circuit values.

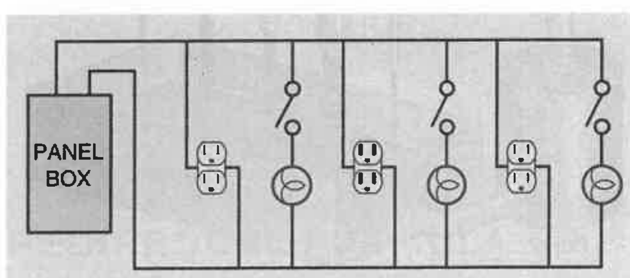

FIGURE 6-3 Lights and receptacles are connected in parallel.

TOTAL RESISTANCE

In the circuit shown in **Figure 6-4**, three separate resistors have values of 15 Ω, 10 Ω, and 30 Ω. The total resistance of the circuit, however, is 5 Ω. **The total resistance of a parallel circuit is always less than the resistance of the lowest-value resistor, or branch, in the circuit.** Each time another element is connected in parallel, there is less opposition to the flow of current through the entire circuit. Imagine a water system consisting of a holding tank, a pump, and return lines to the tank (**Fig. 6-5**). Although large return pipes have less resistance to the flow of water than small pipes, the small pipes do provide a return path to the holding tank. Each time another return path is added, regardless of size, there is less overall resistance to flow, and the rate of flow increases.

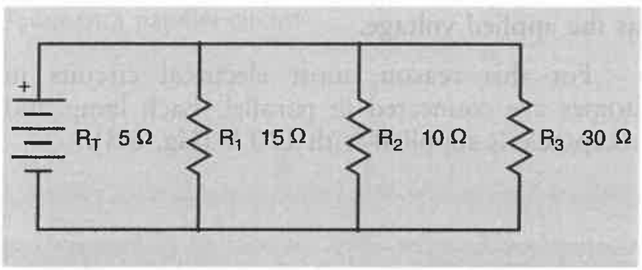

FIGURE 6-4 Total resistance is always less than the resistance of any single branch.

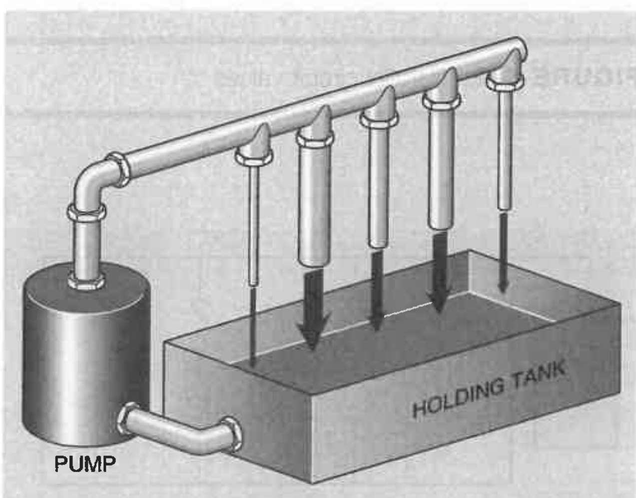

FIGURE 6-5 Each new path reduces the total resistance to the flow of water.

That concept often causes confusion concerning the definition of **load** among students of electricity. Students often think that an increase of resistance constitutes an increase of load. An increase of current, not resistance, results in an increase of load. In laboratory exercises, students often see the circuit current increase each time a resistive element is connected to the circuit, and they conclude that an increase of resistance must, therefore, cause an increase of current. That conclusion is, of course, completely contrary to Ohm's law, which states that an increase of resistance must cause a proportional decrease of current. The false concept that an increase of resistance causes an increase of current can be overcome once the student understands that if the resistive elements are being connected in parallel, the circuit resistance is actually being decreased and not increased.

PARALLEL RESISTANCE FORMULAS

RESISTORS OF EQUAL VALUE

Three formulas can be used to determine the total resistance of a parallel circuit. The first formula shown can be used only when all the resistors in the circuit are of equal value. This formula states that **when all resistors are of equal value the total resistance is equal to the value of one individual resistor, or branch, divided by the number (N) of resistors or branches.**

$$R_T = \frac{R}{N}$$

For example, assume that three resistors, each having a value of 24 Ω, are connected in parallel (**Fig. 6-6**). The total resistance of this circuit can be

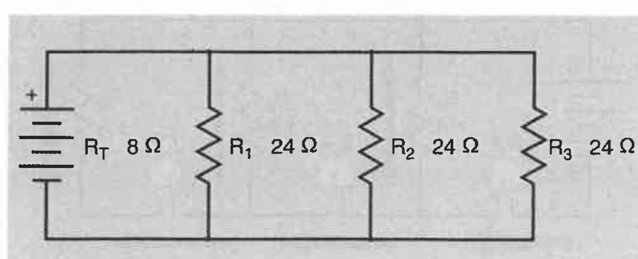

FIGURE 6-6 Finding the total resistance when all resistors have the same value.

found by dividing the resistance of one single resistor by the total number of resistors.

$$R_T = \frac{R}{N}$$

$$R_T = \frac{24}{3}$$

$$R_T = 8\,\Omega$$

PRODUCT OVER SUM

The second formula used to determine the total resistance in a parallel circuit divides the product of pairs of resistors by their sum sequentially until only one pair is left. This is commonly referred to as the **product over sum formula** for finding total resistance.

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

In the circuit shown in **Figure 6-7**, three branches having resistors with values of 20 Ω, 30 Ω, and 60 Ω are connected in parallel. To find the total resistance of the circuit using the product over sum method, find the total resistance of any two branches in the circuit (Fig. 6-8).

$$R_T = \frac{R_2 \times R_3}{R_2 + R_3}$$

$$R_T = \frac{30 \times 60}{30 + 60}$$

$$R_T = \frac{1800}{90}$$

$$R_T = 20\,\Omega$$

The total resistance of the last two resistors in the circuit is 20 Ω. This 20 Ω, however, is

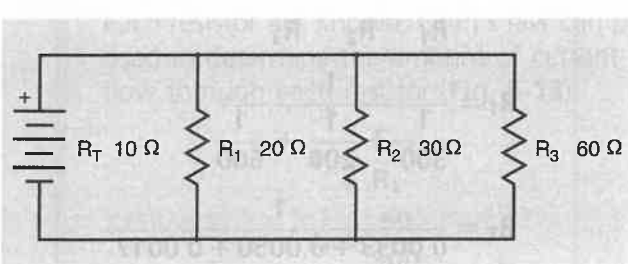

FIGURE 6-7 Finding the total resistance of a parallel circuit by dividing the product of two resistors by their sum.

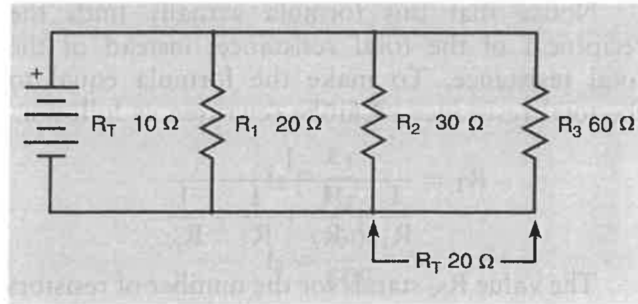

FIGURE 6-8 The total resistance of the last two branches.

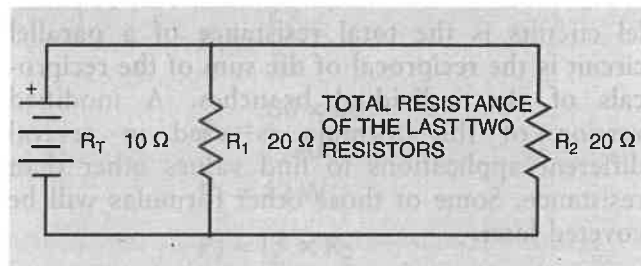

FIGURE 6-9 The total value of the first two resistors is used as resistor 2.

connected in parallel with a 20 Ω resistor. The total resistance of the last two resistors is now substituted for the value of R_1 in the formula, and the value of the first resistor is substituted for the value of R_2 (Fig. 6-9).

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

$$R_T = \frac{20 \times 20}{20 + 20}$$

$$R_T = \frac{400}{40}$$

$$R_T = 10\,\Omega$$

RECIPROCAL FORMULA

The third formula used to find the total resistance of a parallel circuit is

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

Notice that this formula actually finds the reciprocal of the total resistance, instead of the total resistance. To make the formula equal to the total resistance it can be rewritten as follows:

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

The value R_N stands for the number of resistors in the circuit. If the circuit has 25 resistors connected in parallel, for example, the last resistor in the formula would be R_{25}.

This is known as the **reciprocal formula.** The reciprocal of any number is that number divided into 1. The reciprocal of 4, for example, is 0.25 because 1/4 = 0.25. Another rule of parallel circuits is **the total resistance of a parallel circuit is the reciprocal of the sum of the reciprocals of the individual branches.** A modified version of this formula is used in several different applications to find values other than resistance. Some of those other formulas will be covered later.

Before the invention of hand-held calculators, the slide rule was often employed to help with the mathematical calculations in electrical work. At that time, the product over sum method of finding total resistance was the most popular. Since the invention of calculators, however, the reciprocal formula has become the most popular, because scientific calculators have a reciprocal key (1/X), which makes computing total resistance using the reciprocal method very easy.

In **Figure 6-10**, three resistors having values of 150 Ω, 300 Ω, and 100 Ω are connected in parallel. The total resistance can be found using the reciprocal formula.

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

$$R_T = \frac{1}{\frac{1}{150} + \frac{1}{300} + \frac{1}{100}}$$

$$R_T = \frac{1}{0.006667 + 0.003333 + 0.01}$$

$$R_T = \frac{1}{0.02}$$

$$R_T = 50\,\Omega$$

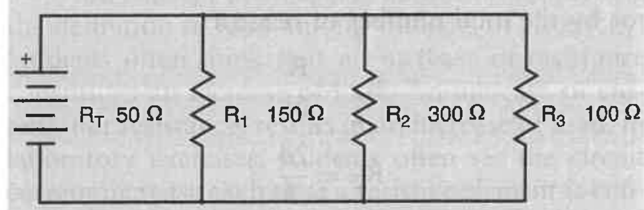

FIGURE 6-10 Finding the total resistance using the reciprocal method.

EXAMPLE 1

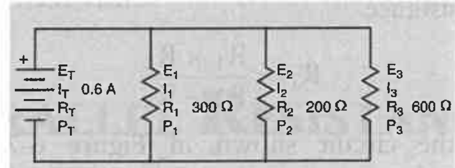

FIGURE 6-11 Parallel circuit, Example 1.

In the circuit shown in **Figure 6-11**, three resistors having values of 300 Ω, 200 Ω, and 600 Ω are connected in parallel. The total current flow through the circuit is 0.6 A. Find all the missing values in the circuit.

Solution

The first step is to find the total resistance of the circuit. The reciprocal formula will be used.

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

$$R_T = \frac{1}{\frac{1}{300} + \frac{1}{200} + \frac{1}{600}}$$

$$R_T = \frac{1}{0.0033 + 0.0050 + 0.0017}$$

$$R_T = \frac{1}{0.01}$$

$$R_T = 100\,\Omega$$

EXAMPLE 1 CONTINUED

Now that the total resistance of the circuit is known, the voltage applied to the circuit can be found using the total current value and Ohm's law.

$$E_T = I_T \times R_T$$

$$E_T = 0.6 \times 100$$

$$E_T = 60\ V$$

One of the rules for parallel circuits states that the voltage drops across all the parts of a parallel circuit are the same as the total voltage. Therefore, the voltage drop across each resistor is 60 V (**Fig. 6-12**).

$$E_T = E_1 = E_2 = E_3$$

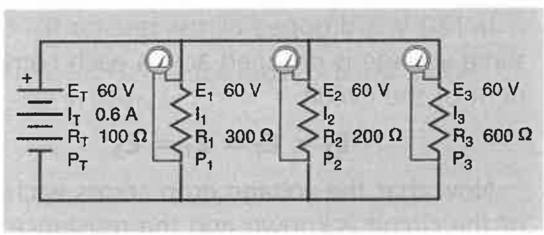

FIGURE 6-12 The voltage is the same across all branches of a parallel circuit.

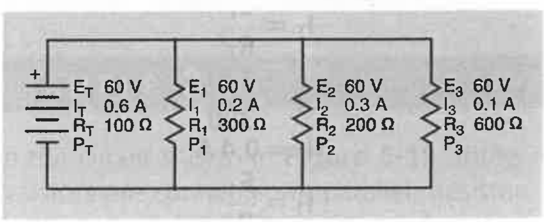

FIGURE 6-13 Ohm's law is used to compute the amount of current through each branch.

Since the voltage drop and resistance of each resistor are known, Ohm's law can be used to determine the amount of current flow through each resistor (**Fig. 6-13**).

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

$$I_1 = \frac{60}{300}$$

$$I_1 = 0.2\ A$$

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

$$I_2 = \frac{60}{200}$$

$$I_2 = 0.3\ A$$

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

$$I_3 = \frac{60}{600}$$

$$I_3 = 0.1\ A$$

The amount of power (watts) used by each resistor can be found using Ohm's law. A different formula will be used to find the amount of electrical energy converted into heat by each of the resistors.

$$P_1 = \frac{E_1^2}{R_1}$$

$$P_1 = \frac{60 \times 60}{300}$$

$$P_1 = 12\ W$$

$$P_2 = I_2^2 \times R_2$$

$$P_2 = 0.3 \times 0.3 \times 200$$

$$P_2 = 18\ W$$

$$P_3 = E_2 \times I_3$$

$$P_3 = 60 \times 0.1$$

$$P_3 = 6\ W$$

In **Chapter 5**, it was stated that the total amount of power in a circuit is equal to the sum of the power used by all the parts. This is true for any type of circuit. Therefore, the total amount of power used by this circuit can be found by taking the sum of the power used by all the resistors (**Fig. 6-14**).

$$P_T = P_1 + P_2 + P_3$$

$$P_T = 12 + 18 + 6$$

$$P_T = 36\ W$$

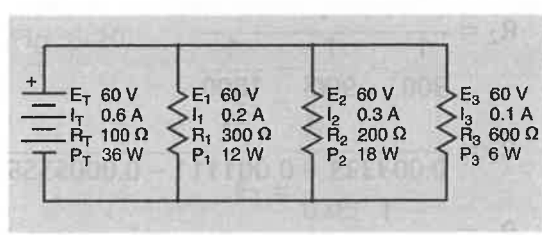

FIGURE 6-14 The amount of power used by the circuit.

EXAMPLE 2

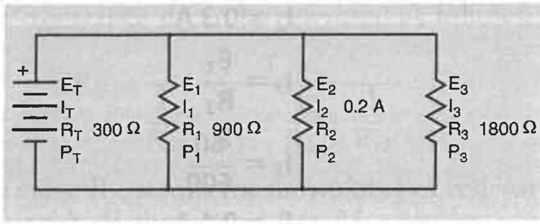

FIGURE 6-15 Parallel circuit, Example 2.

In the circuit shown in **Figure 6-15**, three resistors are connected in parallel. Two of the resistors have a value of 900 Ω and 1800 Ω. The value of resistor R_2 is unknown. The total resistance of the circuit is 300 Ω. Resistor R_2 has a current flow of 0.2 A. Find the missing circuit values.

Solution

The first step in solving this problem is to find the missing resistor value. This can be done by changing the reciprocal formula as shown:

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

or

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

One of the rules for parallel circuits states that the total resistance is equal to the reciprocal of the sum of the reciprocals of the individual resistors. Therefore, the reciprocal of any individual resistor is equal to the reciprocal of the difference between the reciprocal of the total resistance and the sum of the reciprocals of the other resistors in the circuit.

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

$$R_2 = \frac{1}{\frac{1}{300} - \frac{1}{900} - \frac{1}{1800}}$$

$$R_2 = \frac{1}{0.003333 - 0.001111 - 0.0005556}$$

$$R_2 = \frac{1}{0.001666}$$

$$R_2 = 600\ \Omega$$

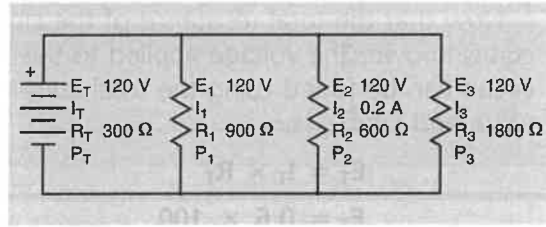

FIGURE 6-16 The missing resistor and voltage values.

Now that the resistance of resistor R_2 has been found, the voltage drop across resistor R_2 can be determined using the current flow through the resistor and Ohm's law (**Fig. 6-16**).

$$E_2 = I_2 \times R_2$$
$$E_2 = 0.2 \times 600$$
$$E_2 = 120\ \text{V}$$

If 120 V is dropped across resistor R_2, the same voltage is dropped across each component of the circuit.

$$E_2 = E_T = E_1 = E_3$$

Now that the voltage drop across each part of the circuit is known and the resistance is known, the current flow through each branch can be determined using Ohm's law (**Fig. 6-17**).

$$I_T = \frac{E_T}{R_T}$$
$$I_T = \frac{120}{300}$$
$$I_T = 0.4\ \text{A}$$
$$I_1 = \frac{E_1}{R_1}$$
$$I_1 = \frac{120}{900}$$
$$I_1 = 0.1333\ \text{A}$$
$$I_3 = \frac{E_3}{R_3}$$
$$I_3 = \frac{120}{1800}$$
$$I_3 = 0.0666\ \text{A}$$

The amount of power used by each resistor can be found using Ohm's law (**Fig. 6-18**).

$$P_1 = \frac{E_1^2}{R_1}$$
$$P_1 = \frac{120 \times 120}{900}$$
$$P_1 = 16\ \text{W}$$
$$P_2 = I_2^2 \times R_2$$

EXAMPLE 2 CONTINUED

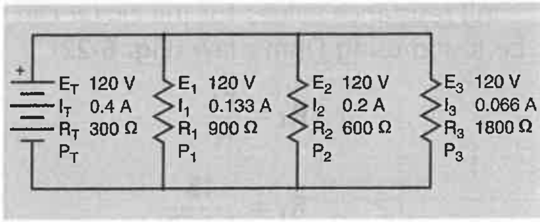

FIGURE 6-17 Determining the current using Ohm's law.

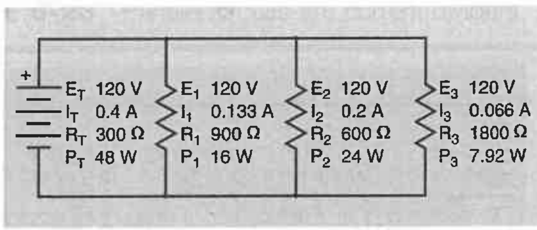

FIGURE 6-18 The values of power for the circuit in Example 2.

$$P_2 = 0.2 \times 0.2 \times 600$$

$$P_2 = 24\ W$$

$$P_3 = E_3 \times I_3$$

$$P_3 = 120 \times 0.066$$

$$P_3 = 7.92\ W$$

$$P_T = E_T \times I_T$$

$$P_T = 120 \times 0.4$$

$$P_T = 48\ W$$

If the wattage values of the three resistors are added to compute total power for the circuit, it will be seen that their total is 47.92 W instead of the computed 48 W. The small difference in answers is caused by the rounding off of other values. In this instance, the current of resistor R_3 was rounded from 0.066666666 to 0.066.

EXAMPLE 3

In the circuit shown in **Figure 6-19**, three resistors are connected in parallel. Resistor R_1 is producing 0.075 W of heat, R_2 is producing 0.45 W of heat, and R_3 is producing 0.225 W of heat. The circuit has a total current of 0.05 A.

Solution

Since the amount of power dissipated by each resistor is known, the total power for the circuit can be determined by finding the sum of the power used by the components.

$$P_T = P_1 + P_2 + P_3$$

$$P_T = 0.075 + 0.45 + 0.225$$

$$P_T = 0.75\ W$$

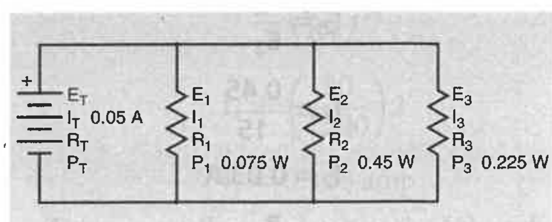

FIGURE 6-19 Parallel circuit, Example 3.

Now that the amount of total current and total power for the circuit are known, the applied voltage can be found using Ohm's law (**Fig. 6-20**).

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

$$E_T = \frac{0.75}{0.05}$$

$$E_T = 15\ V$$

EXAMPLE 3 CONTINUED

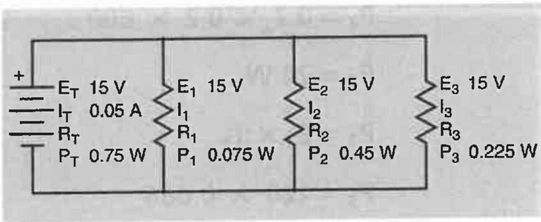

FIGURE 6-20 The applied voltage for the circuit.

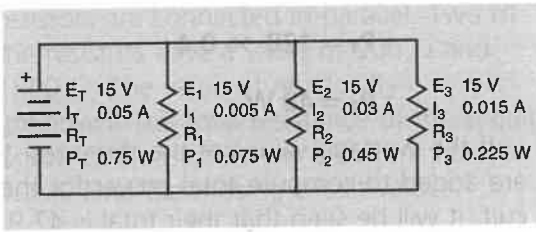

FIGURE 6-21 The current through each branch.

The amount of current flow through each resistor can now be found using Ohm's law (**Fig. 6-21**).

$$I_1 = \frac{P_1}{E_1}$$

$$I_1 = \frac{0.075}{15}$$

$$I_1 = 0.005\ \text{A}$$

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

$$I_2 = \frac{0.45}{15}$$

$$I_2 = 0.03\ \text{A}$$

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

$$I_3 = \frac{0.225}{15}$$

$$I_3 = 0.015\ \text{A}$$

All resistance values for the circuit can now be found using Ohm's law (**Fig. 6-22**).

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

$$R_1 = \frac{15}{0.005}$$

$$R_1 = 3000\ \Omega$$

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

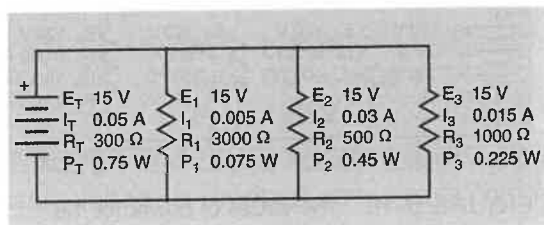

FIGURE 6-22 The remaining values for the circuit.

$$R_2 = \frac{15}{0.03}$$

$$R_2 = 500\ \Omega$$

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

$$R_3 = \frac{15}{0.015}$$

$$R_3 = 1000\ \Omega$$

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

$$R_T = \frac{15}{0.05}$$

$$R_T = 300\ \Omega$$

CURRENT DIVIDERS

All parallel circuits are *current dividers* (Fig. 6-23). As previously discussed in this chapter, the sum of the currents in a parallel circuit must equal the total current. Assume that a current of 1 ampere enters the circuit at point A. This 1 ampere of current will divide between resistors R_1 and R_2, and then recombine at point B. The amount of current that flows through each resistor is proportional to the resistance value. A greater amount of current will

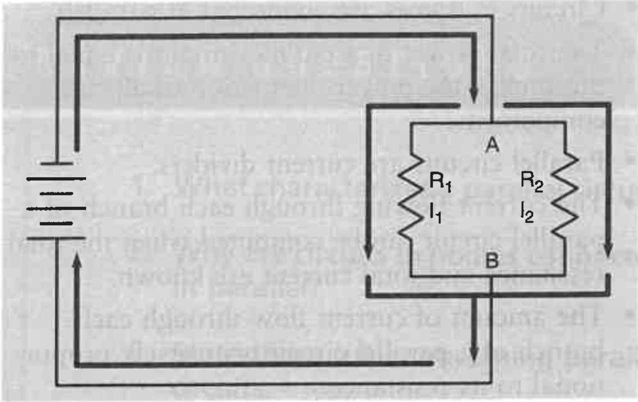

FIGURE 6-23 Parallel circuits are current dividers.

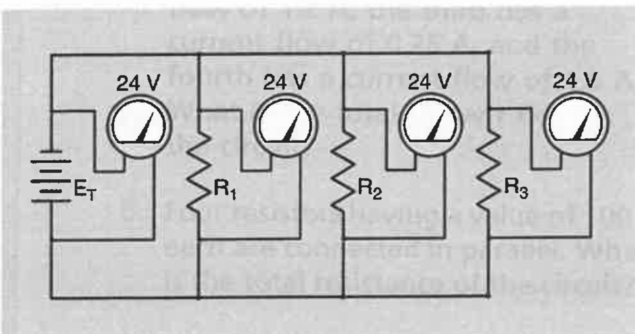

FIGURE 6-24 The voltage is the same across all branches of a parallel circuit.

flow through a low value resistor and less current will flow through a high value resistor. In other words, the amount of current flowing through each resistor is inversely proportional to its resistance.

In a parallel circuit, the voltage across each branch must be equal (**Fig. 6-24**). Therefore, the current flow through any branch can be computed by dividing the source voltage (E_T) by the resistance of that branch. The current flow through branch #1 can be computed using the formula

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

It is also true that the total circuit voltage is equal to the product of the total circuit current and the total circuit resistance.

$$E_T = I_T \times R_T$$

If the value of E_T is substituted for ($I_T \times R_T$) in the previous formula, it becomes

$$I_1 = \frac{I_T \times R_T}{R_1}$$

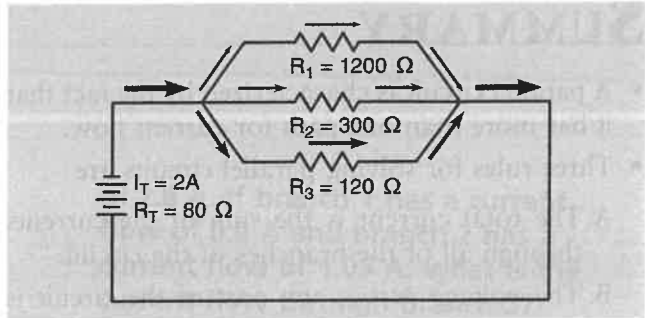

FIGURE 6-25 The current divides through each branch of a parallel circuit.

If the formula is rearranged, and the values of I_1 and R_1 are substituted for I_X and R_X, it becomes what is generally known as the **current divider formula.**

$$I_X = \left(\frac{R_T}{R_X}\right) I_T$$

This formula can be used to compute the current flow through any branch by substituting the values of I_X and R_X for the branch values when the total circuit current and resistance are known. In the circuit shown in **Figure 6-25**, resistor R_1 has a value of 1200 Ω, resistor R_2 has a value of 300 Ω, and resistor R_3 has a value of 120 Ω, producing a total of resistance of 80 Ω for the circuit. It is assumed that a total current of 2 amps flows in the circuit. The amount of current flow through resistor R_1 can be found using the formula.

$$I_1 = \left(\frac{R_T}{R_1}\right) I_T$$

$$I_1 = \left(\frac{80}{1200}\right) 2$$

$$I_1 = 0.133 \text{ amp}$$

The current flow through each of the other resistors can be found by substituting in the same formula.

$$I_2 = \left(\frac{R_T}{R_2}\right) I_T$$

$$I_2 = \left(\frac{80}{300}\right) 2$$

$$I_2 = 0.533 \text{ amp}$$

$$I_3 = \left(\frac{R_T}{R_3}\right) I_T$$

$$I_3 = \left(\frac{80}{120}\right) 2$$

$$I_3 = 1.333 \text{ amp}$$

SUMMARY

- A parallel circuit is characterized by the fact that it has more than one path for current flow.
- Three rules for solving parallel circuits are

  A. The total current is the sum of the currents through all of the branches of the circuit.

  B. The voltage across any part of the circuit is the same as the total voltage.

  C. The total resistance is the reciprocal of the sum of the reciprocals of each individual branch.
- Circuits in homes are connected in parallel.
- The total power in a parallel circuit is equal to the sum of the power dissipation of all the components.
- Parallel circuits are current dividers.
- The current flowing through each branch of a parallel circuit can be computed when the total resistance and total current are known.
- The amount of current flow through each branch of a parallel circuit is inversely proportional to its resistance.

REVIEW QUESTIONS

1. What characterizes a parallel circuit?
2. Why are circuits in homes connected in parallel?
3. State three rules concerning parallel circuits.
4. A parallel circuit contains four branches. One branch has a current flow of 0.8 A, another has a current flow of 1.2 A, the third has a current flow of 0.25 A, and the fourth has a current flow of 1.5 A. What is the total current flow in the circuit?
5. Four resistors having a value of 100 Ω each are connected in parallel. What is the total resistance of the circuit?
6. A parallel circuit has three branches. An ammeter is connected in series with the output of the power supply and indicates a total current flow of 2.8 A. If branch 1 has a current flow of 0.9 A and branch 2 has a current flow of 1.05 A, what is the current flow through branch 3?
7. Four resistors having values of 270 Ω, 330 Ω, 510 Ω, and 430 Ω are connected in parallel. What is the total resistance in the circuit?
8. A parallel circuit contains four resistors. The total resistance of the circuit is 120 Ω. Three of the resistors have values of 820 Ω, 750 Ω, and 470 Ω. What is the value of the fourth resistor?
9. A circuit contains a 1,200 Ω, a 2,200 Ω, and a 3,300 Ω resistor connected in parallel. The circuit has a total current flow of 0.25 A. How much current flows through each of the resistors?

PRACTICE PROBLEMS

PARALLEL CIRCUITS

Using the rules for parallel circuits and Ohm's law, solve for the missing values.

1.

E_T	E_1	E_2	E_3	E_4
I_T 0.942	I_1	I_2	I_3	I_4
R_T	R_1 680 Ω	R_2 820 Ω	R_3 470 Ω	R_4 330 Ω
P_T	P_1	P_2	P_3	P_4

2.

E_T	E_1	E_2	E_3	E_4
I_T 0.00639	I_1	I_2 0.00139	I_3 0.00154	I_4 0.00115
R_T	R_1	R_2	R_3	R_4
P_T	P_1 0.640	P_2	P_3	P_4

3.

E_T	E_1	E_2	E_3	E_4
I_T	I_1	I_2	I_3 3.2	I_4
R_T 3.582 Ω	R_1 16 Ω	R_2 10 Ω	R_3	R_4 20 Ω
P_T	P_1	P_2	P_3	P_4

4.

E_T	E_1	E_2	E_3	E_4
I_T	I_1	I_2	I_3	I_4
R_T	R_1 82 kΩ	R_2 75 kΩ	R_3 56 kΩ	R_4 62 kΩ
P_T 3.436	P_1	P_2	P_3	P_4

5. **A parallel circuit contains the following resistor values:**

   $R_1 = 360\ \Omega$ $R_2 = 470\ \Omega$ $R_3 = 300\ \Omega$

   $R_4 = 270\ \Omega$ $I_T = 0.05$ amp

   Find the following missing values:

   $R_T =$ ______ Ω $I_1 =$ ______ A $I_2 =$ ______ A

   $I_3 =$ ______ A $I_4 =$ ______ A

6. **A parallel circuit contains the following resistor values:**

   $R_1 = 270$ KΩ $R_2 = 360$ KΩ $R_3 = 430$ KΩ

   $R_4 = 100$ KΩ $I_T = 0.06$ amp

   Find the following missing values:

   $R_T =$ ______ Ω $I_1 =$ ______ A $I_2 =$ ______ A

   $I_3 =$ ______ A $I_4 =$ ______ A

PRACTICAL APPLICATIONS

1. You have been hired by a homeowner to install a ceiling fan and light kit in his living room. The lighting fixture being used at the present time contains two 60-W lamps. After locating the circuit in the panel box, you find that the circuit is connected to a 15-amp circuit breaker and is run with #14 AWG copper wire. After turning on all loads connected to the circuit, you measure a current draw of 8.6 A and a voltage of 120 V. The ceiling fan light kit contains four 60-W lamps, and the fan motor has a maximum current draw of 1.6 A. Recall that a continuous load should not be more than 80% of the circuit rating. Can the fan and light kit be connected without overloading the circuit?

2. You are an electrician in a large industrial plant. A 480-V 5-kW electric heater is used to melt lead in a tank. It is decided that the 5-kW heater cannot heat the lead to the desired temperature. A second 5-kW heater is to be installed on the same circuit. What will be the circuit current after the installation of the second heater, and what is the minimum size circuit breaker that can be used if this is a continuous-duty load?

3. A car lot uses incandescent lamps to supply outside lighting at night. There are three strings of lamps connected to a single 20-A circuit breaker. Each string contains eight lamps. What is the largest standard lamp size that can be used without overloading the circuit? The standard lamp sizes are 25 W, 40 W, 60 W, 75 W, and 100 W. Since the lamps are intended to operate during the entire night, the circuit is continuous.