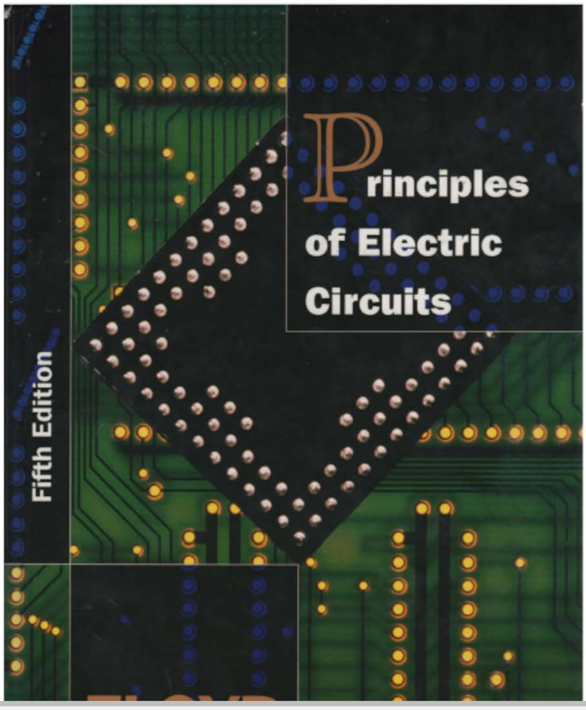

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Now that you know V_4, use Ohm's law to calculate R_4 as follows:

$$R_4 = \frac{V_4}{I} = \frac{68.6\ \text{V}}{200\ \text{mA}} = 343\ \Omega$$

This is most likely a 330 Ω resistor because 343 Ω is within a standard tolerance range (+5%) of 330 Ω.

Related Exercise Determine R_4 in Figure 5–36 for $V_S = 150$ V and $I = 200$ mA.

SECTION 5–6 REVIEW

1. State Kirchhoff's voltage law in two ways.
2. A 50 V source is connected to a series resistive circuit. What is the total of the voltage drops in this circuit?
3. Two equal-value resistors are connected in series across a 10 V battery. What is the voltage drop across each resistor?
4. In a series circuit with a 25 V source, there are three resistors. One voltage drop is 5 V, and the other is 10 V. What is the value of the third voltage drop?
5. The individual voltage drops in a series string are as follows: 1 V, 3 V, 5 V, 8 V, and 7 V. What is the total voltage applied across the series string?

5–7 ■ VOLTAGE DIVIDERS

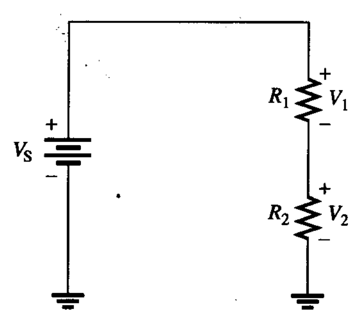
A series circuit acts as a voltage divider. You will learn what this term means and why voltage dividers are an important application of series circuits.

After completing this section, you should be able to

- ■ Use a series circuit as a voltage divider
  - ☐ Apply the voltage-divider formula
  - ☐ Use the potentiometer as an adjustable voltage divider
  - ☐ Describe some voltage-divider applications.

To illustrate how a series string of resistors acts as a voltage divider, we will examine Figure 5–37 where there are two resistors in series. There are two voltage drops: one across R_1 and one across R_2. These voltage drops are V_1 and V_2, respectively, as indicated in the diagram.

FIGURE 5–37
Two-resistor voltage divider.



Since each resistor has the same current, the voltage drops are proportional to the

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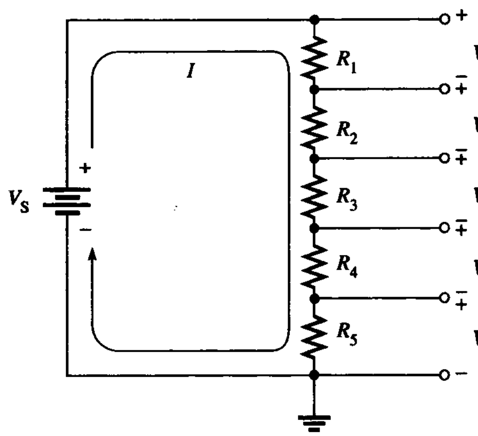
is twice that of V_1. In other words, *the total voltage drop divides among the series resistors in amounts directly proportional to the resistance values.*

For example, in Figure 5–37, if V_S is 10 V, R_1 is 50 Ω, and R_2 is 100 Ω, then V_1 is one-third the total voltage, or 3.33 V, because R_1 is one-third the total resistance (150 Ω). Likewise, V_2 is two-thirds V_S, or 6.67 V.

Voltage-Divider Formula

With a few steps, a formula for determining how the voltages divide among series resistors can be developed. Let's assume that we have several resistors in series as shown in Figure 5–38. This figure shows five resistors as an example, but there can be any number.

FIGURE 5–38
Five-resistor voltage divider.



Let's call the voltage drop across any one of the resistors V_x, where x represents the number of a particular resistor (1, 2, 3, and so on). By Ohm's law, the voltage drop across any of the resistors in Figure 5–38 can be written as follows:

$$V_x = IR_x$$

where x = 1, 2, 3, 4, or 5.

The current is equal to the source voltage divided by the total resistance ($I = V_S/R_T$). For the example circuit of Figure 5–38, the total resistance is $R_1 + R_2 + R_3 + R_4 + R_5$. Substituting V_S/R_T for I in the expression for V_x results in

$$V_x = \left(\frac{V_S}{R_T}\right)R_x$$

Rearranging the terms yields

$$V_x = \left(\frac{R_x}{R_T}\right)V_S \qquad \textbf{(5–5)}$$

Equation (5–5) is the general voltage-divider formula. It can be stated as follows:

> **The voltage drop across any resistor or combination of resistors in a series circuit is equal to the ratio of that resistance value to the total resistance, multiplied by the source voltage.**

The following three examples illustrate use of the voltage-divider formula.

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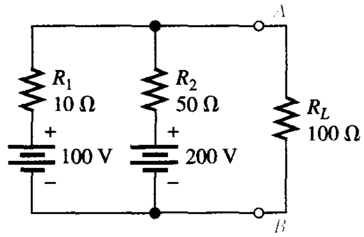
SECTION 8–7 REVIEW

1. To what type of circuit does Millman's theorem apply?
2. Write the Millman theorem formula for R_{EQ}.
3. Write the Millman theorem formula for V_{EQ}.
4. Find the load current (I_L) and the load voltage (V_L) in Figure 8–54.

FIGURE 8–54



8–8 ■ MAXIMUM POWER TRANSFER THEOREM

The maximum power transfer theorem is important when you need to know the value of the load at which the most power is delivered from the source.

After completing this section, you should be able to

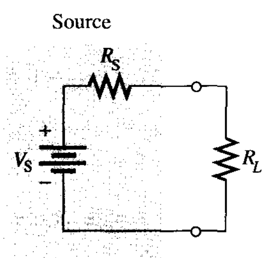
- **Apply the maximum power transfer theorem**
  - ☐ State the theorem
  - ☐ Determine the value of load resistance for which maximum power is transferred from a given circuit

The **maximum power transfer** theorem states as follows:

> **When a source is connected to a load, maximum power is delivered to the load when the load resistance is equal to the internal source resistance.**

The source resistance, R_S, of a circuit is the equivalent resistance as viewed from the output terminals using Thevenin's theorem. An equivalent circuit with its output resistance and load is shown in Figure 8–55. When $R_L = R_S$, the maximum power possible is transferred from the voltage source to R_L.

FIGURE 8–55
Maximum power is transferred to the load when $R_L = R_S$.



Practical applications of this theorem include audio systems such as stereo, radio, and public address. In these systems the resistance of the speaker is the load. The circuit that drives the speaker is a power amplifier. The systems are typically optimized for maximum power to the speakers. Thus, the resistance of the speaker must equal the internal source resistance of the amplifier.

Example 8–16 shows that maximum power occurs when $R_L = R_S$.

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