The voltage and current divider circuits

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Lecture Four

The voltage and current divider circuits

4.1 The voltage-divider circuit

Voltage-divider circuit, shown in **Fig.4.1**. We analyze this circuit by directly applying Ohm's law and Kirchhoff's laws. To aid the analysis we introduce the current ***I*** as shown in **Fig.4.1 (b)**. From Kirchhoff's current law $\mathbf{R_1}$ and $\mathbf{R_2}$, carry the same current. Applying **Kirchhoff's voltage law** around the closed loop yields

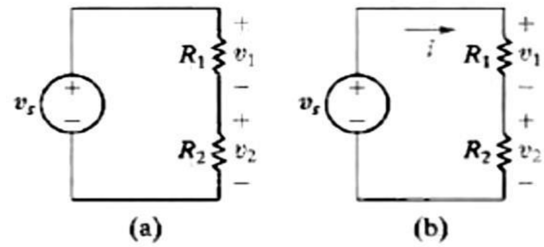


Figure 4.1 (a) A voltage-divider circuit and (b) The voltage-divider circuit with current i indicated

$$\mathbf{Vs = I\,R_1 + I\,R_2},$$

Now we can use Ohm's law to calculate v_1 and, v_2:

$$v_1 = \frac{R_1\,v_s}{R_1 + R_2}, \quad v_2 = \frac{R_2\,v_s}{R_1 + R_2} \qquad (4.1)$$

In general, if a voltage divider has **N** resistors ($\mathbf{R_1, R_2, \ldots, R_N}$) in series with the source voltage v_s, the Nth resistor ($\mathbf{R_N}$) will have a voltage drop of

$$v_N = \frac{R_N\,v_s}{R_1 + R_2 + \cdots + R_N} = \frac{R_N\,v_s}{R_{eq}} \qquad (4.2)$$

4.2 The current-divider circuit

The **current-divider circuit** shown in **Fig. 4.2.** The current divider is designed to divide the current i_s between $\mathbf{R_1}$ and $\mathbf{R_2}$. We find the relationship between the current i_s, and the current in each resistor (that is, i_1 and i_2) by directly applying **Ohm's law and Kirchhoff's current law**. The voltage across the parallel resistors is

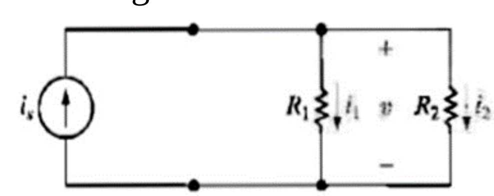


Figure 4.2 the current-divider circuit.

$$V = i_1 R_1 = i_2 R_2 = \frac{R_1 R_2}{R_1 + R_2} i_s$$

$$i_1 = \frac{R_2\, i_s}{R_1 + R_2}, \quad i_2 = \frac{R_1\, i_s}{R_1 + R_2} \qquad (4.3)$$

If we divide both the numerator and denominator by $\mathbf{R_1R_2}$, **Eq. (2.16)** become

$$i_1 = \frac{G_1\, i_s}{G_1 + G_2}, \quad i_2 = \frac{G_2\, i_s}{G_1 + G_2} \qquad (4.4)$$

Thus, in general, if a current divider has **N** conductors ($\mathbf{G_1, G2, \ldots, G_N}$) in parallel with the source current i, the nth conductor ($\mathbf{G_N}$) will have current

$$i_N = \frac{G_N\, i_s}{G_1 + G_2 + \cdots + G_N} = \frac{R_{eq}\, i_s}{R_N} \qquad (4.5)$$

Example 2.3: Find $\boldsymbol{i_o}$ and $\boldsymbol{v_o}$ in the circuit shown in **Fig. 4.3(a)**. Calculate the power dissipated in the 3-Ω resistor.

Solution: The 6-Ω and 3-Ω resistors are in parallel, so their combined resistance is

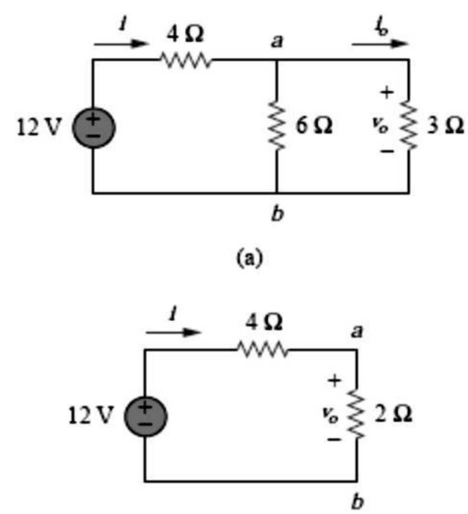


Figure 4.3 (a) Original circuit, (b) Its equivalent circuit.

$$\mathbf{6\ \Omega \parallel 3\ \Omega = 6 \times 3/ (6 + 3) = 2\ \Omega}$$

By apply voltage division, since the 12 V in **Fig. 4.3(b)** is divided between the 4-Ω and 2-Ω resistors. Hence,

$$\mathbf{v_o = 2(12\ V)/(2 + 4) = 4\ V}$$

Apply current division to the circuit in **Fig. 4.3(a)** now that we know **i**, by writing

$$\mathbf{i = 12/\ 4 + 2 = 2\ A}$$

$$\mathbf{i_o = 6\ i\ /(6 + 3) = 4\ /3\ A}$$

The power dissipated in the 3-Ω resistor is

$$\mathbf{p_o = v_o\ i_o = 4(4/3) = 5.333\ W}$$

Example 4.2: Find the voltage drop at the resister 4Ω in the circuit shown in Fig.4.4

Solution:

$$\mathbf{V(4\Omega)} = \frac{\mathbf{24 \times 4\Omega}}{\mathbf{2\Omega + 4\Omega + 6\Omega}} = \mathbf{8}\ \boldsymbol{v}$$

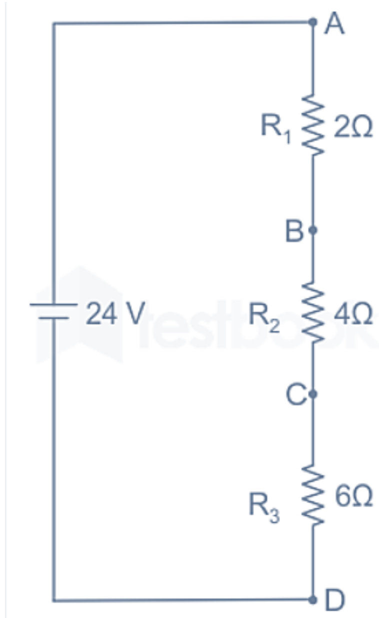


Figure. 4.4

Example 4.3: Find the current through the resister 8Ω in the circuit shown in Fig.4.5

Solution:

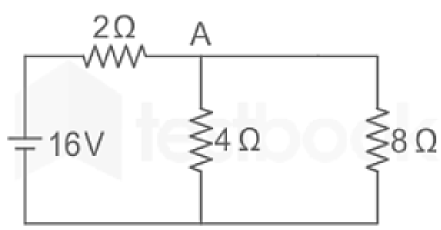


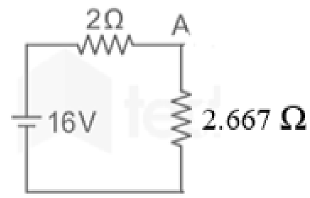
Figure. 4.5

The 8-Ω and 4-Ω resistors are in parallel, so their combined resistance is

8Ω || 4 Ω = 8 × 4/ (8 + 4) = 2.667 Ω

By using the voltage divider rule the voltage at (2.667 Ω) is

$$\mathbf{V(2.667\Omega)} = \frac{\mathbf{16 \times 2.667\Omega}}{\mathbf{2\Omega + 2.667\Omega}} = \mathbf{9.143}\ \boldsymbol{v}$$



The voltage at 8Ω is 9.143v (parallel connected)

The current through 8Ω is

$$\mathbf{i(8\Omega)} = \frac{\mathbf{9.143}}{\mathbf{8}} = \mathbf{1.14}\ \boldsymbol{A}$$

Thank You