ELECTRIC CIRCUITS

Ohm's Law

$V = I \cdot R$ (Some books use $E = I \cdot R$)

where: V = voltage (volts or V)

I = current (amperes or amps or A)

R = resistance (ohms or Ω)

Equivalent Resistance

Series Resistance:

Given resistors R1, R2, R3, …, RN; connected in series.

The equivalent resistance is given by the formula:

$$REQ = R1 + R2 + R3 + \ldots + RN$$

Parallel Resistance:

Given resistors R1, R2, R3, …, RN; connected in parallel.

The equivalent resistance is given by the formula:

$$1 / REQ = 1 / R1 + 1 / R2 + 1 / R3 + \ldots + 1 / RN$$

$$\frac{1}{REQ} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \ldots + \frac{1}{RN}$$

For the “special” case (or short cut) of two resistors (R1 and R 2) connected in parallel, the formula becomes:

$$REQ = (R1 \cdot R2) / (R1 + R2)$$

$$REQ = \frac{R1 \cdot R2}{R1 + R2}$$

Voltage Law

The voltage changes around any closed loop in an electric circuit must sum to zero.

Voltage Divider Rule

For a circuit with two resistors, R1 and R2, in series, the voltage drop across each resistor equals the resistance times the total voltage, divided by the sum of the two resistors.

$$V_1 = \frac{V_s \cdot R1}{(R1 + R2)}$$

$$V_2 = \frac{V_s \cdot R2}{(R1 + R2)}$$

Current Law

The electric current which flows into any junction in an electric circuit is equal to the current which flows out.

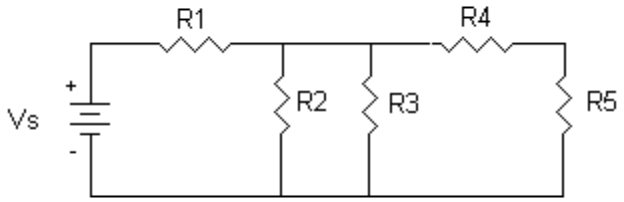
Current Divider Rule

For two parallel resistors, R1 and R2, the current through the branch equals the resistance of the opposite branch times the input current divided by the sum of the two resistors.

$$I_1 = \frac{I \cdot R2}{(R1 + R2)}$$

$$I_2 = \frac{I \cdot R1}{(R1 + R2)}$$

Circuit Example



If R1 = 24 Ω, R2 = 24 Ω, R3 = 12 Ω, R4 = 12 Ω, R5 = 12 Ω and Vs = 12 Volts, determine the circuit equivalent resistance (REQ) and the circuit current (I). Also calculate the branch currents through R2, R3, R4, and R5, and the voltage drops across R1, R2, R3, R4 and R5.

Solution

Calculate R45 (Series Resistance)

R45 = R4 + R5 = 12 + 12
R45 = 24 Ω

Calculate R345 (Parallel Resistance)

1/R345 = 1/R3 + 1/R45 = 1/12 + 1/24 = 2/24 + 1/24 = 3/24
Therefore, R345 = 8 Ω

Calculate R2345 (Parallel Resistance)

1/R2345 = 1/R2 + 1/R345 = 1/24 + 1/8 = 1/24 + 3/24 = 4/24
Therefore, R2345 = 6 Ω

Calculate REQ (Series Resistance)

REQ = R1 + R2345 = 24 Ω + 6 Ω
REQ = 30 Ω

Calculated the circuit current. Use Ohm's Law $V = I \cdot R$
$12\ V = I \cdot 30\ \Omega$
Therefore, I = 12/30
I = 0.4 A

Calculate the voltage drop across R1
$V1 = I \cdot R1 = 0.4\ A \cdot 24\ \Omega$
V1 = 9.6 V

Calculate the voltage drops across R2 and R3
V2 = V3 = 12 V - 9.6 V
V2 = V3 = 2.4 V

Calculate the current through R2
$I2 = V2 / R2 = 2.4\ V / 24\ \Omega$
I2 = 0.1 A

Calculate the current through R3
$I3 = V3 / R3 = 2.4\ V / 12\ \Omega$
I3 = 0.2 A

Calculate the current through R4 and R5
The voltage drop across R45 = V2 = V3 = 2.4 V
Therefore $I4 = I\ 5 = V45 / R45 = 2.4\ V / 24\ \Omega$
I4 = I5 = 0.1 A

Finally, calculate the voltage drops across R4 and R5
$V4 = I4 \cdot R4 = 0.1\ A \cdot 12\ \Omega$
V4 = 1.2 V

$V5 = I5 \cdot R5 = 0.1\ A \cdot 12\ \Omega$
V5 = 1.2 V