Circuit elements are categorized into:

Passive elements are:

1-Resistor المقاوم

2- Inductor اداة الحث

3- Capacitor مكثف

Active elements such as

1-Voltage source like batteries

2-Current source

3-Generators

4-Operational amplifier

There are two types of elements found in electric circuits: ***passive*** elements and ***active*** elements. An active element is capable of generating energy while a passive element is not.

1-Passive elements

1.1 Resistance of the material:

The flow of charge through any material encounters an opposing force due to the collisions between electrons and between electrons and other atoms in the material, ***which converts electrical energy into another form of energy such as heat***, is called the **resistance** of the material . The unit of measurement of resistance is the **ohm,** for which the symbol is (Ω)
The circuit symbol for resistance appears in Fig. (1.1)

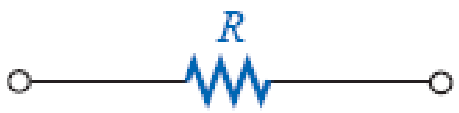


Fig. 1-1

Resistance symbol

The resistance of any material with a uniform cross-sectional area is determined by the following four factors:

1. Material resistivity
2. Length
3. Cross-sectional area
4. Temperature

Conductors will have low resistance levels, while insulators will have high resistance characteristics.

At a fixed temperature of 20°C (room temperature), the resistance is related to the other three factors by:

$$R = \rho \frac{l}{A} \quad \text{(ohms, } \Omega\text{)} \qquad (1.1)$$

ρ:	ohm-centimeters
l:	centimeters
A:	square centimeters

Where ρ (Greek letter rho) is a characteristic of the material called the resistivity, l is the length of the sample, and A is the cross-sectional area of the sample.

1-2 (a) Temperature effect (T)

For good **conductors,** an increase in temperature will result in an increase in the resistance level. Consequently, conductors have a positive temperature coefficient. Fig (2-1-a)

For **semiconductor** materials, an increase in temperature will result in a decrease in the resistance level. Consequently, semiconductors have negative temperature coefficients. Fig (2-1-b)

As with semiconductors, an increase in temperature will result in a decrease in the resistance of an **insulator.** The result is a negative temperature coefficient.

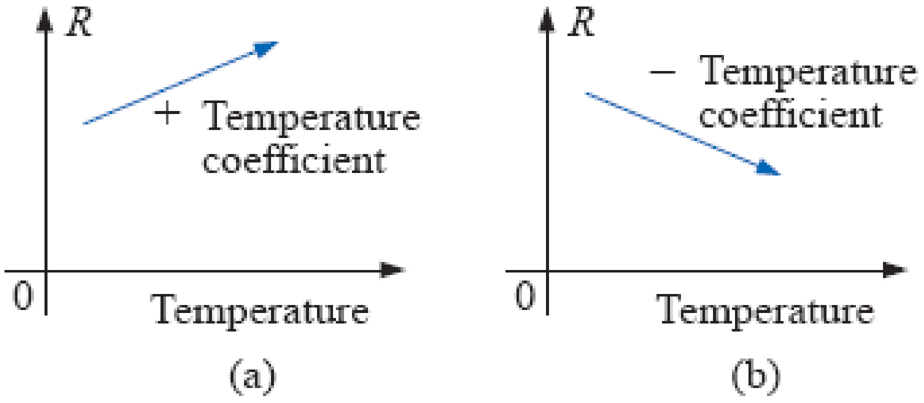


Fig 1-2
(a) Positive temperature coefficient for conductors.
(b) Negative temperature coefficient for semiconductors and insulators.

1-2(b) Inferred Absolute Temperature(درجة الحرارة المطلقة المُسْتَنْتجة الصحيحة)

The proper inferred absolute temperature may be written as follows:

$$\frac{|T_i| + T_1}{R_1} = \frac{|T_i| + T_2}{R_2} \qquad \text{---------------------1.2)}$$

where |*Ti*| indicates that the inferred absolute temperature of the material involved is inserted as a positive value in the equation. In general, therefore, associate the sign only with $T1$ and $T2$.

EXAMPLE 1-1 If the resistance of a copper wire is 50 Ω at 20°C, what is its resistance at 100°C (boiling point of water)?
Note: Inferred absolute temperatures (Ti).of the copper is 234.5°

Solution:

$$\frac{234.5°\text{C} + 20°\text{C}}{50\ \Omega} = \frac{234.5°\text{C} + 100°\text{C}}{R_2}$$

$$R_2 = \frac{(50\ \Omega)(334.5°\text{C})}{254.5°\text{C}} = \mathbf{65.72\ \Omega}$$

EXAMPLE 1-2 If the resistance of aluminum wire at room temperature (20°C) is 100 mΩ(measured by a milliohm meter), at what temperature will its resistance increase to 120 mΩ?

Solution:

$$\frac{236°\text{C} + 20°\text{C}}{100\ \text{m}\Omega} = \frac{236°\text{C} + T_2}{120\ \text{m}\Omega}$$

$$T_2 = 120\ \text{m}\Omega\left(\frac{256°\text{C}}{100\ \text{m}\Omega}\right) - 236°\text{C}$$

$$T_2 = \mathbf{71.2°C}$$

Ex. 1-3 if the resistance of a copper wire at freezing (0°C) is 30 **Ω** what is its resistance at -40°C?

Sol.

$$\frac{234.5°\text{C} + 0}{30\ \Omega} = \frac{234.5°\text{C} - 40°\text{C}}{R_2}$$

$$R_2 = \frac{(30\ \Omega)(194.5°\text{C})}{234.5°\text{C}} = \mathbf{24.88\ \Omega}$$

1-3 CONDUCTANCE (G)

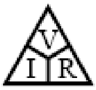
By finding the reciprocal of the resistance of a material, we have a measure of how well the material will conduct electricity. The quantity is called **conductance,** has the symbol *G,* and is measured in *Siemens* (S)**.**

$$G = \frac{1}{R} \quad \text{(siemens, S)} \qquad \text{------------------ (1-3)}$$

In equation form, the conductance is determined by:

$$G = \frac{A}{\rho l} \quad \text{(S)} \qquad \text{------------------ (1-4)}$$

1-4 Ohms law



$$R = \frac{E}{I} \quad \text{(ohms, } \Omega\text{)}$$

Or

$$I = \frac{E}{R} \quad \text{(amperes, A)}$$

Or

$$E = IR \quad \text{(volts, V)}$$

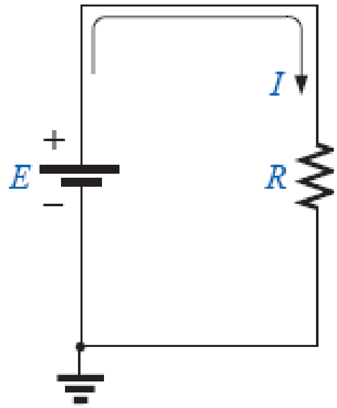


Fig 1-3

Basic circuit

Ex.1-4 Determine the current resulting from the application of a 9V battery across a network with a resistance of 2.2 Ω.

Sol.

$$I = \frac{E}{R} = \frac{9\text{ V}}{2.2\ \Omega} = \mathbf{4.09\ A}$$

Ex. 1-5 Calculate the voltage that must be applied across the soldering iron of Fig. 1-4 to establish a current of 1.5 A through the iron if its internal resistance is 80 Ω.

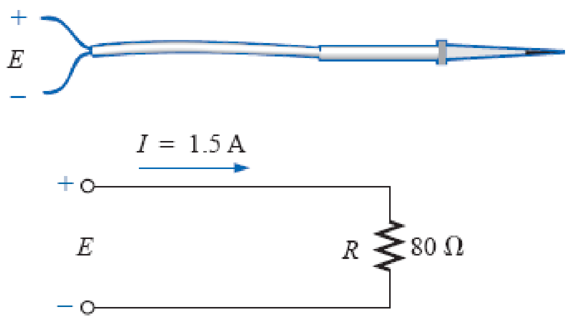


Fig1-4

Sol.

$$E = IR = (1.5\text{ A})(80\ \Omega) = \mathbf{120\ V}$$

1-5 POWER

power and energy calculations are important in circuit analysis.
Power is an indication of how much work (the conversion of energy from one form to another) can be done in a specified amount of time, that is, a *rate* of doing work. For instance, a large motor has more Power than a small motor because it can convert more electrical energy into mechanical energy in the same period of time. Since converted energy is measured in *joules* (J) and time in seconds (s), power is measured in joules/second (J/s). The electrical unit of measurement for power is the watt (W),

Power is the time rate of expending or absorbing energy, measured in watts (W).

$$P = \frac{W}{t} \qquad \text{(watts, W, or joules/second, J/s)}$$

$$1 \text{ watt (W)} = 1 \text{ joule/second (J/s)}$$

$$1 \text{ horsepower} \cong 746 \text{ watts}$$

$$P = \frac{W}{t} = \frac{QV}{t} = V\frac{Q}{t}$$

But $I = \dfrac{Q}{t}$

so that $P = VI$ (watts)

$$P = VI = V\left(\frac{V}{R}\right)$$

and $$P = \frac{V^2}{R} \quad \text{(watts)}$$

or $$P = VI = (IR)I$$

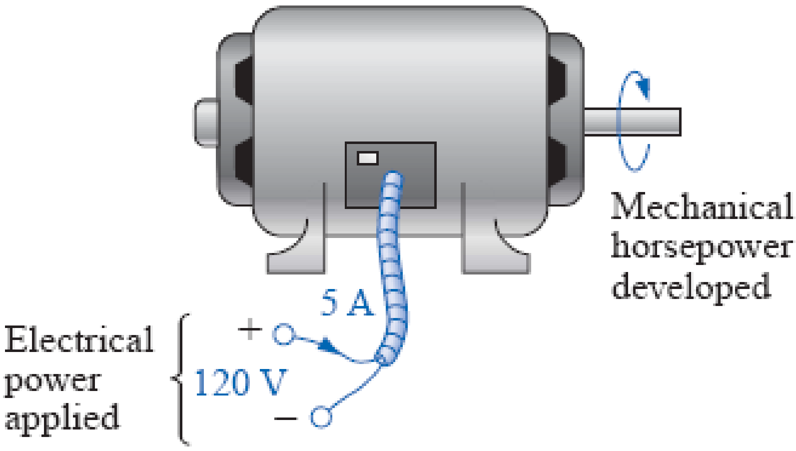
and $$P = I^2R \quad \text{(watts)}$$

The magnitude of the power delivered or absorbed by a battery is given by

$$P = EI \quad \text{(watts)}$$

With E the battery terminal voltage and I the current through the source

EXAMPLE 1-6 Find the power delivered to the dc motor of Fig 1-5:



Sol.

$$P = VI = (120\text{ V})(5\text{ A}) = 600\text{ W} = \mathbf{0.6\ kW}$$

EXAMPLE 1-7 what is the power dissipated by a 5Ω resistor if the current is 4 A?

Sol.

$$P = I^2R = (4\text{ A})^2(5\ \Omega) = \mathbf{80\ W}$$

2- Active elements

2-1 Voltage source and current source

The most important active elements are voltage or current sources that generally deliver power to the circuit connected to them. There are two kinds of sources:

a. Independent sourses
b. dependent sources

> An **ideal independent source** is an active element that provides a specified voltage or current that is completely independent of other circuit variables.

An independent voltage source delivers to the circuit whatever current is necessary to maintain its terminal voltage batteries and generators may be regarded as approximations to ideal voltage sources. Figure 2-1 shows the symbols for independent voltage sources.

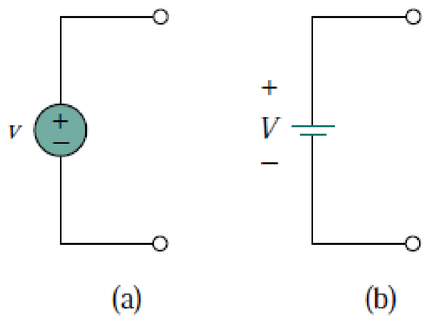


Fig2-1
Symbols for independent voltage sources:
(a) Used for constant or time-varying voltage,
(b) Used for constant voltage (dc).

An ideal independent current source is an active element that provides a specified current completely independent of the voltage across the source That is, the current source delivers to the circuit whatever voltage is necessary to maintain the designated current. The symbol for an independent current source is displayed in Fig. 2-2, where the arrow indicates the direction of current *i*.

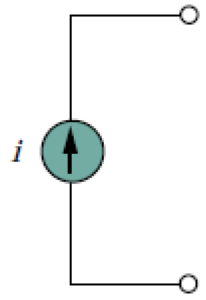


Fig2-2
Symbol for independent current source.

Dependent sources are usually designated by diamond-shaped symbols, as shown in Fig. 2-3.

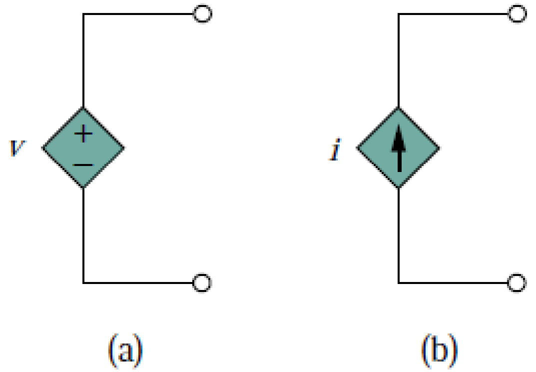


Fig 2-3
Symbols for:
(a) Dependent voltage source,
(b) Dependent current source

Dependent sources are useful in modeling elements such as transistors, operational amplifiers and integrated circuits.

An ideal dependent (or controlled) source is an active element in which the source quantity is controlled by another voltage or current.

NOTE

1- The term (ideal source) means that the internal resistance (R_s) of the source (voltage source or current source) equal zero.

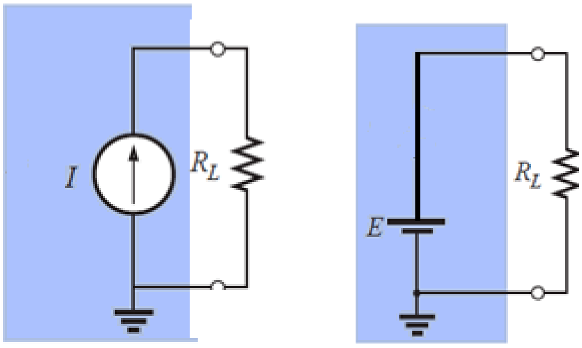


Fig 2-4

Ideal sources

2- The term (actual source) means that there is an internal resistance (R_s) of the source (voltage source or current source).

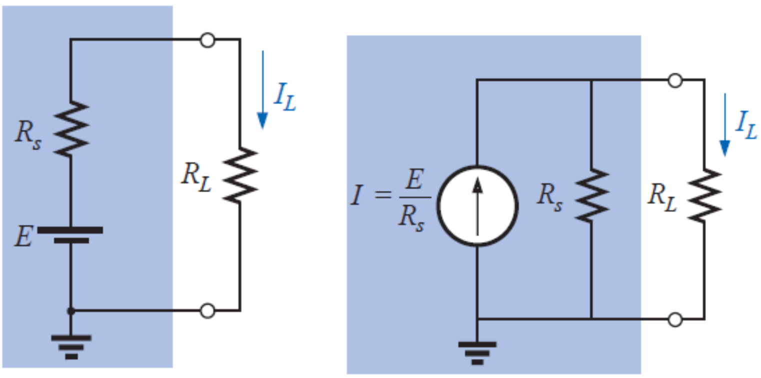


Fig 2-5

Actual sources

Please read and try understand in the first reference Chapter 1, 2, 3, and 4.

References:

1- **Introductory Circuits Analysis, By Boylested, Tenth (10th) Edition.**

2- **Schaum's Outline of Theory and Problems of Basic Circuit Analysis, By John O'Malley, Second (2nd) Edition.**

3- **Any reference that has Direct Current Circuits Analysis (DCCA).**