Lesson 1.3: Electrical Quantities

Objective:

At the end of the lesson, the trainee will be able to:

1. Define the current, voltage, resistance and power
2. Understand the flow of the real current.
3. Identify the symbols and units of current, voltage, resistance and power.
4. Convert the unit of resistance, current, voltage and power.
5. Differentiate between alternating current (AC) and direct current (DC) supply.

Current is defined as the rate of flow of electrical charge inside a conductor.

الاختصار I

Abbreviation of current is **I**

Unit of current is **Ampere** (A).

الوحدة ← A

Scientific Notation of Current shown in Table 1.

kilo Ampere (kA)	(1×10^{3} Ampere)
Ampere (A)	(1×10^{0} Ampere)
milli-Ampere mA	(1×10^{-3} Ampere)
micro-Ampere µA	(1×10^{-6} Ampere)

Table 1: Scientific notation of current

$1\ kA = 1 \times 10^{3}\ A$

$1\ A = 1 \times 10^{0}\ A$

$1\ mA = 1 \times 10^{-3}\ A.$

$1\ \mu A = 1 \times 10^{-6}\ A.$

التيار الكهربي ← معدل سريان الشحنات الكهربية (الالكترونات) في موصل.

هو معدل تغير الشحنات الكهربية بالنسبة للزمن

الشحنة الكهربية I

كولوم C

الزمن s

Φ

t

دالة function

$\Phi = 2t^2 - 2$

دالة في الزمن

$\Phi = 2\ C$

$t = 2\ s.$

$I = \frac{dq}{dt}$.

Types of current

1. Direct Current (DC) - A current that is constant in both magnitude and direction all the time. A current that comes out from a battery is a good example of a (DC) source. **Figure 1** shows the DC waveform.

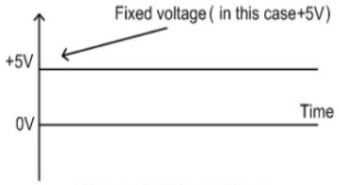


Figure 1: DC waveform

2. Alternating Current (AC) - A current that changes its magnitude and direction over a period of time. A current that comes out from the receptacle outlet is a good example of an (AC) source. **Figure 2** shows AC waveform.

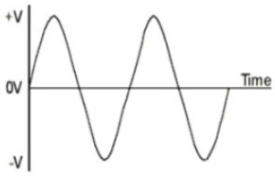
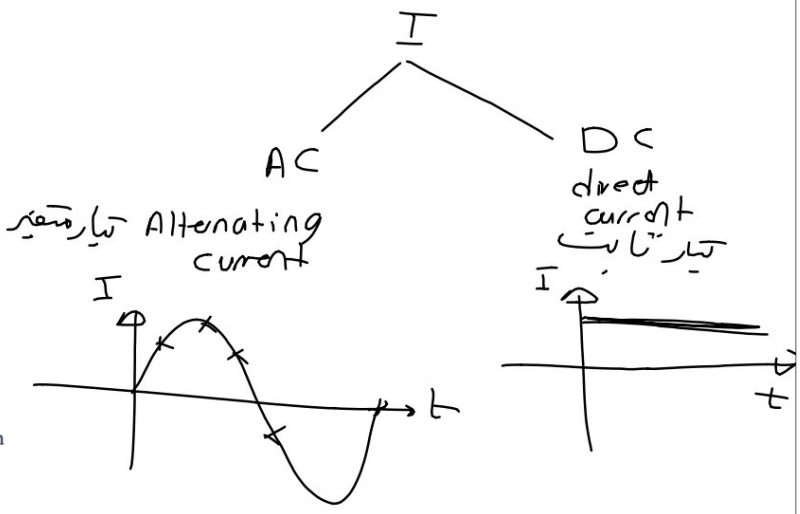


Figure 2: AC waveform



Voltage is the external force that causes electrons to flow. Voltage is represented by the letter "**E**" for internal voltage source and by "**V**" for terminal voltage of the supply (behind the voltage drop in the internal supply impedance).

Abbreviation of voltage is **"V"** or **"E"**.
Unit of voltage is **Volt (V)**

Scientific notation of voltage shown in **Table 2**

kilo Volt (kV)	(1×10^{3} Volt)
Volt (V)	(1×10^{0} Volt
milli-Volt (mV)	(1×10^{-3} Volt)
micro-Volt (μV)	(1×10^{-6} Volt)

Table 2: Scientific notation of voltage

الجهد الكهربي ← القوة التي تتسبب
في سريان الشحنات الكهربية (الالكترونات)

E V

V الوحدة ← الفولت

Types of Voltage

1. DC Voltage - a voltage that is constant in both magnitude and direction all the time. The voltage of a battery is a good example of a DC voltage. See in **Figure 3** and **Figure 4**

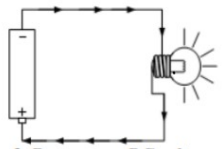


Figure 3: Battery as a DC voltage source

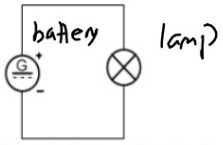
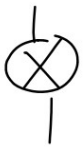


Figure 4: Schematic Circuit



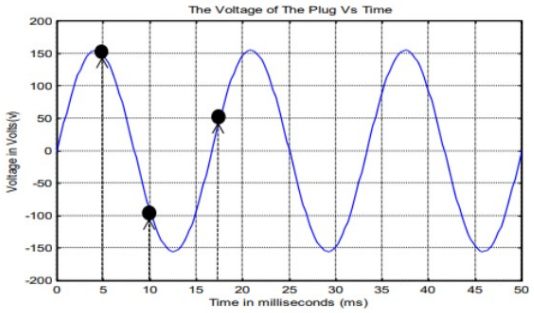


Figure 7: Voltage waveform with respect to time

2. AC Voltage is a voltage that changes its magnitude and direction over a period of time. The 110V volt source from an outlet is a good example of an AC voltage shown in **Figure 5**

110V Receptacle outlet

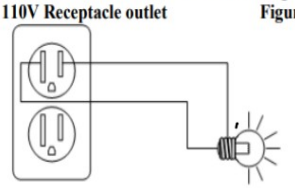


Figure 5: 110V Receptacle outlet

Figure 6: schematic Circuit

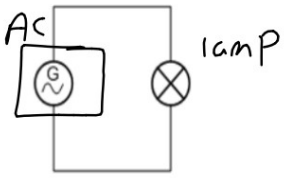
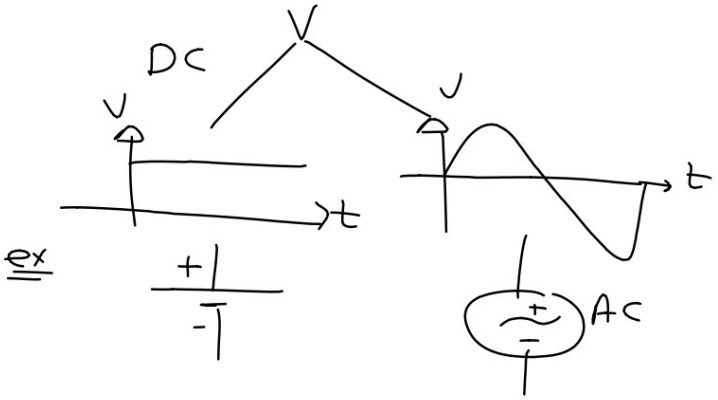


Figure 6: schematic Circuit



Resistance is the property of a material that describes how much resistance opposes the flow of current.

Abbreviation of resistor is **R**

Unit of resistor **Ohms (Ω)**

Symbol of resistor shown in **Figure 9**

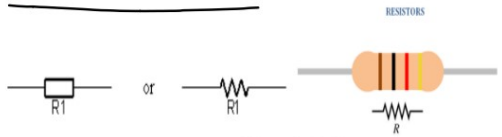


Figure 9: Resistor

Scientific notation of resistance shown in **Table 3**

Tera Ohm (TΩ)	$(1 \times 10^{12}\ \Omega)$
Giga (GΩ)	$(1 \times 10^{9}\ \Omega)$
Mega Ohm (MΩ)	$(1 \times 10^{6}\ \Omega)$
kilo Ohm (kΩ)	$(1 \times 10^{3}\ \Omega)$
Ohm (Ω)	$(1 \times 10^{0}\ \Omega$
milli-Ohm (mΩ)	$(1 \times 10^{-3}\ \Omega)$
micro-Ohm (μΩ)	$(1 \times 10^{-6}\ \Omega)$

Table 3: Scientific notation of resistance in Ohm (Ω)

Lesson 1.4: Insulators and Conductors

Insulators are the type of materials that has high resistance such as wood, glass, plastic and rubber.
Conductors are the type of materials that has low resistance such as copper, gold and etc.

Examples of Insulators and conductors shown in **Figure 10**

Figure 10: Examples of conductors and insulators

material المواد

موصلة conductors. | semiconductor الشبه موصلة | العازلة insulators

جيدة التوصيل للكهرباء

$I = \uparrow\uparrow$

$R \simeq 0 \downarrow\downarrow$

I علاقة عكسية R

Cu النحاس

Au الذهب

Ag silver الفضة

$I \simeq 0 \downarrow\downarrow$

$R \uparrow\uparrow$

rubber المطاط

glass الزجاج

wood الخشب

plastic

Lesson 1.6: Measurements and Accuracy

All test instruments have an intrinsic error. This measurement error, or accuracy, is due to a variety of causes (friction, component tolerance, etc.).

A differentiation is made between:

The Relative error, ε_r of individual measurements can be determined by the formula.

$$\varepsilon r = \frac{True\ Value - Measured\ value}{True\ value} x100$$

القيمة الحقيقية ← True value

القيمة العملية ← measured

Example 1:

The true value (TV) of a resistor is 2,300 Ω ±10% and the measured value (MV) is 2,250 Ω.

What is the relative error?

$$\varepsilon r = \frac{2300 - 2250}{2300} \times 100\%$$

$$= 2.17\%$$

Lesson 1.7: Classifications of Resistors

1. Fixed
2. Variables

Fixed resistors

The fixed resistor is the most common type. It is made of tiny bits of carbon packed together in the shape of a cylinder. The values of fixed resistors are from less than one ohm to millions of ohms. The ohmic value of the resistor is shown by numbers or color bands. The resistance values can also be printed on the resistor.

All fixed resistors, no matter what size, shape, or material are shown on schematic diagrams by the same symbol. The construction and symbol for a fixed resistor is shown in **Figure 18.**

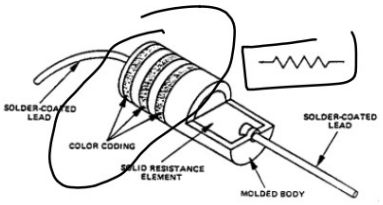
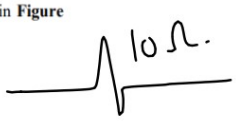
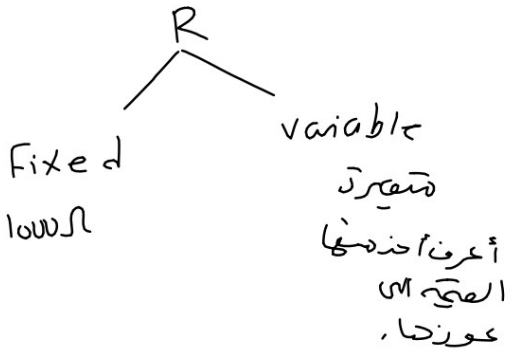


Figure 18: Fixed Resistor





Variable Resistors

The most common variable resistor is the potentiometer. A potentiometer is a variable resistor with two fixed connections and a center connection with a movable contact arm. The moveable contact arm is a mechanical device. Its position determines the amount of tapped resistance. The resistance can be varied from zero to the value stamped on the case. **Figure 19** shows the schematic symbol for a potentiometer and a common carbon potentiometer.

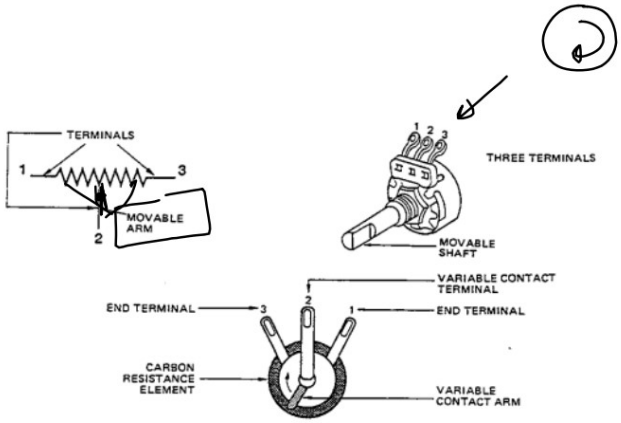
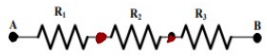


Figure 19: Variable resistor

Lesson 1.9: Resistors in Series Circuit

It is a circuit in which resistors are arranged in a chain and there are no wires branching off from the node between components. **Figure** 23 shows series resistor.



$$R_T = R_1 + R_2 + R_3$$

Figure 23: Series Resistors

Example 1

Calculate the total resistance (R_T) between terminals A and B shown in **Figure 24**.

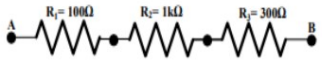


Figure 24: Series circuit

$$Req = 100 + 1000 + 300$$
$$= 1400\ \Omega$$

Example 1

Calculate the total resistance in terminals A and B as shown in **Figure 31**.

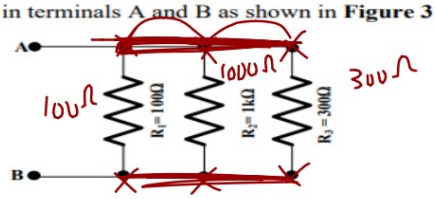


Figure 31

Solution:

$$Req = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = 22.55\Omega.$$

R_1: 100Ω, R_2: 1000Ω, R_3: 300Ω

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

Example 2

Calculate the total resistance of the circuit shown in **Figure 36.**

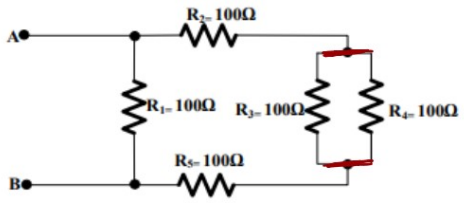
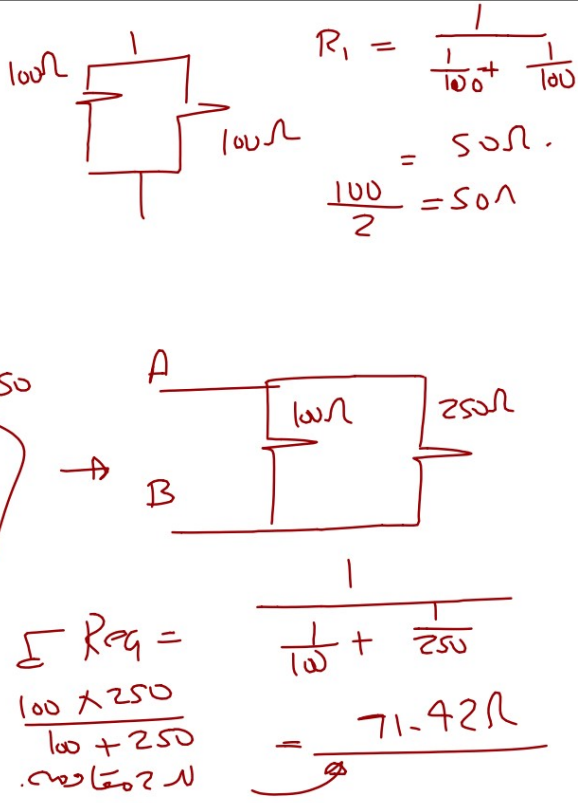
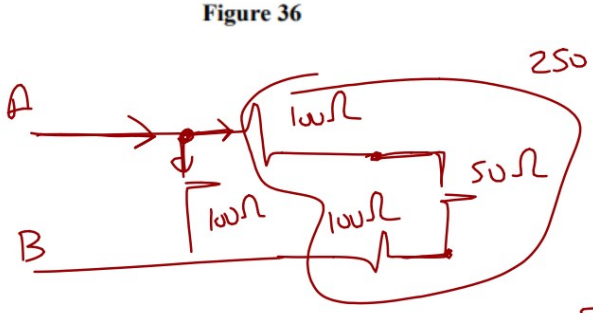


Figure 36





$\therefore R_{eq} = \frac{1}{\frac{1}{100} + \frac{1}{250}}$

$= 71.42\Omega$

$\frac{100 \times 250}{100 + 250}$