

Voltage and current

General

introduction

Now that the foundation for the study of electricity/electronics has been established, the concepts of voltage and current can be investigated. The term **voltages** encountered practically every day.

We have all replaced batteries in our flashlights, answering machines, calculators, automobiles, and so on, that had specific voltage ratings. We are aware that most outlets in our homes are 220 volts.

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ATOMS AND THEIR STRUCTURE

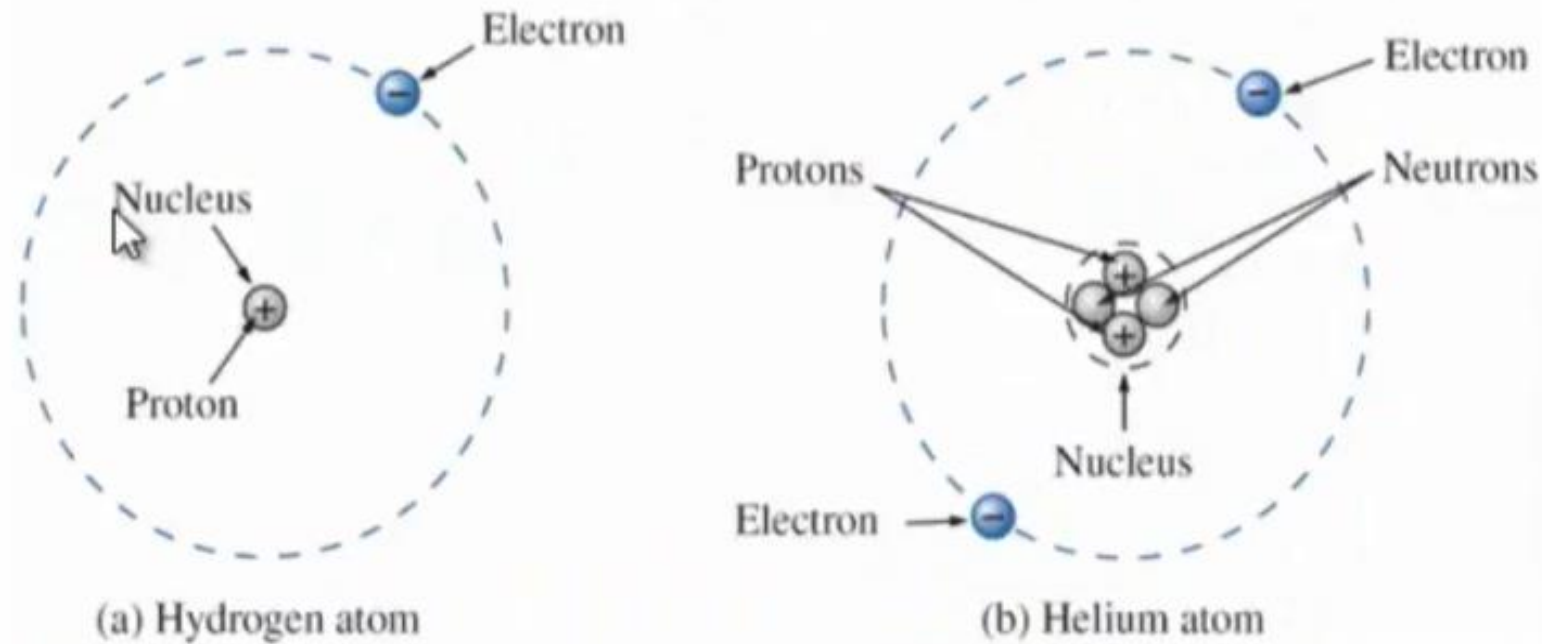


FIG. 2.1 *Hydrogen and helium atoms.*

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Copper is the most commonly used metal in the electrical/electronics industry.

An examination of its atomic structure will reveal why it has such widespread application.

It has 29 electrons in orbits around the nucleus, with the 29th electron appearing all by itself in the 4th shell.

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ATOMS AND THEIR STRUCTURE

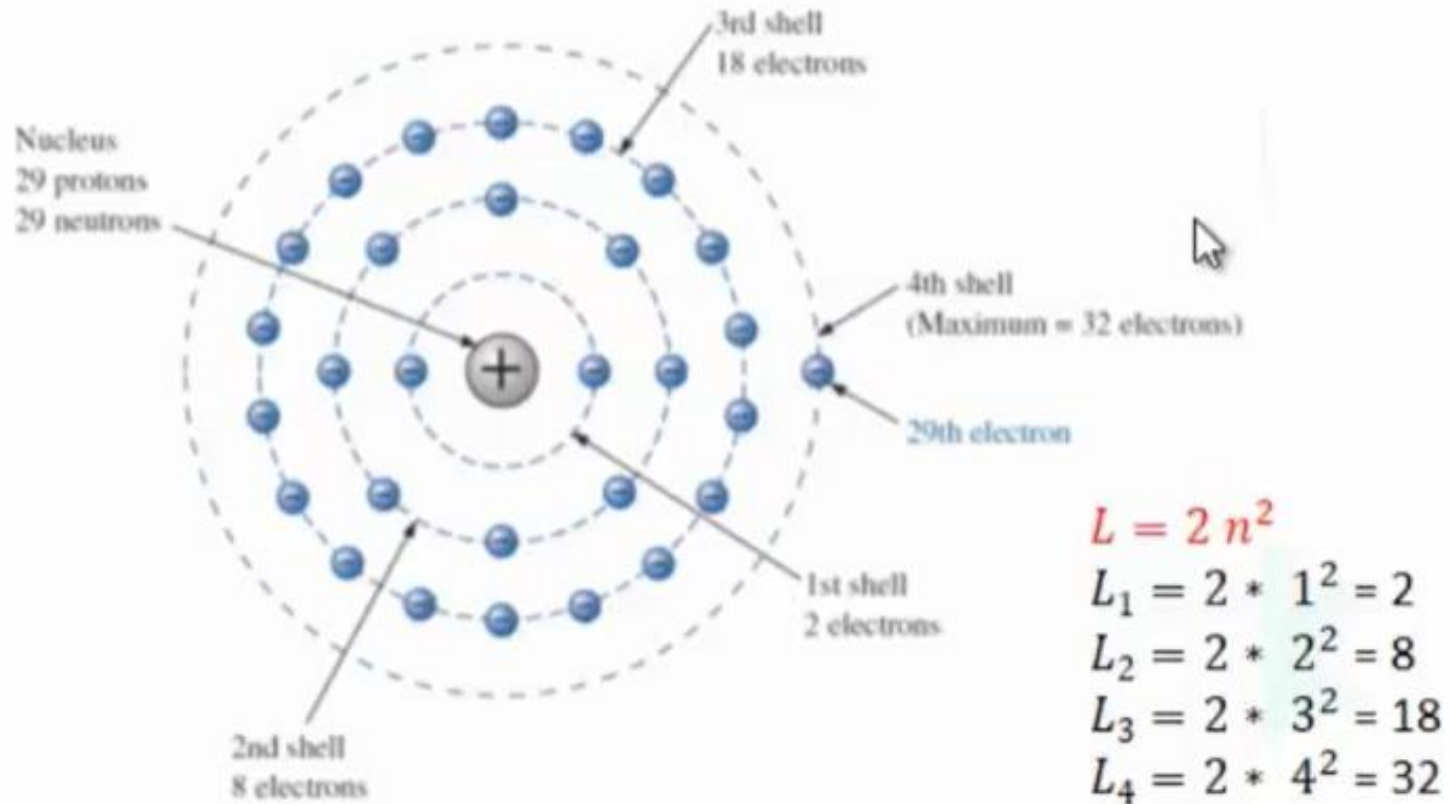


FIG. 2.2 *The atomic structure of copper.*

Voltage

VOLTAGE

If we separate the 29th electron in Fig. 2.2 from the rest of the atomic structure of copper by a dashed line as shown in Fig. 2.3 we create regions that have a net positive and negative charge as shown in Fig.

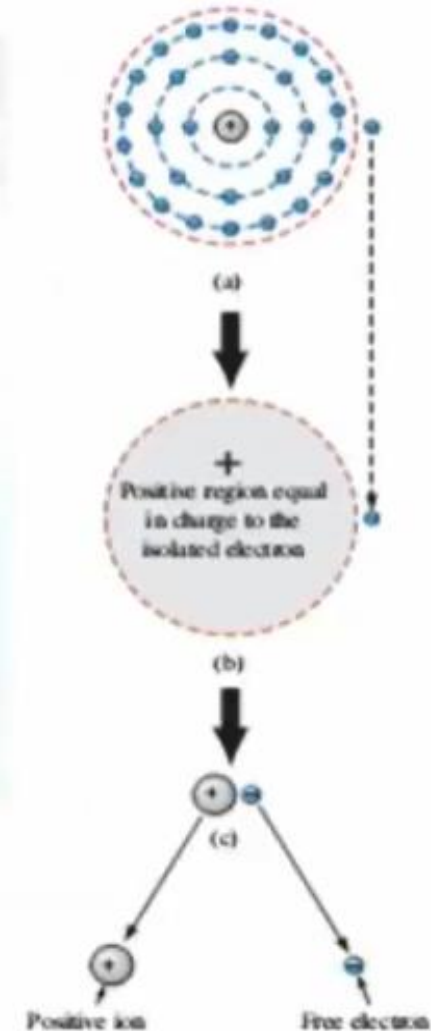


FIG. 2.3 *Defining the positive ion.*

Voltage

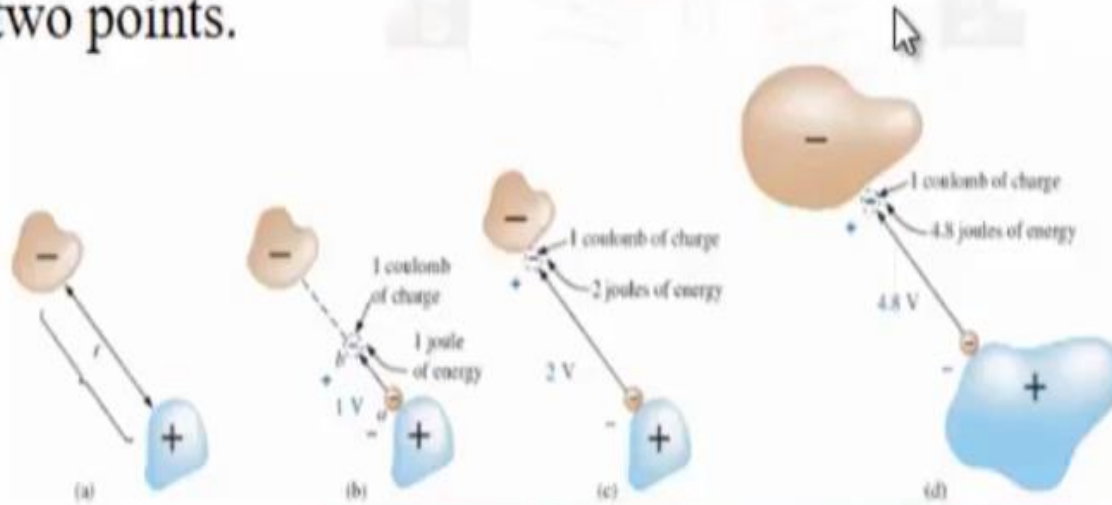
VOLTAGE

- This positive region created by separating the free electron from the basic atomic structure is called a **positive ion**.
- In general, every source of voltage is established by simply creating a separation of positive and negative charges.

Voltage

VOLTAGE

A potential difference of 1 volt (V) exists between two points if 1 joule (J) of energy is exchanged in moving 1 coulomb (C) of charge between the two points.



In general, the potential difference between two points is determined by

$$V = \frac{W}{Q} \quad (\text{volts})$$

Examples

EXAMPLE 2.3 Find the potential difference between two points in an electrical system if 60 J of energy are expended by a charge of 20 C between these two points.

Solution: Eq. (2.6):

$$V = \frac{W}{Q} = \frac{60 \text{ J}}{20 \text{ C}} = 3 \text{ V}$$

EXAMPLE 2.4 Determine the energy expended moving a charge of 50 μC through a potential difference of 6 V.

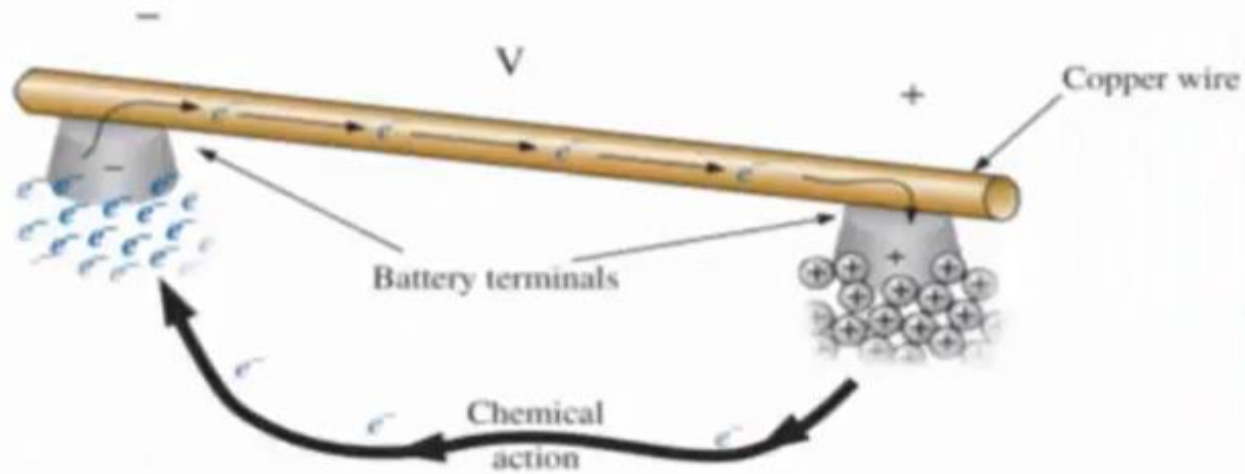
Solution: Eq. (2.7):

$$W = QV = (50 \times 10^{-6} \text{ C})(6 \text{ V}) = 300 \times 10^{-6} \text{ J} = 300 \mu\text{J}$$

Current

CURRENT

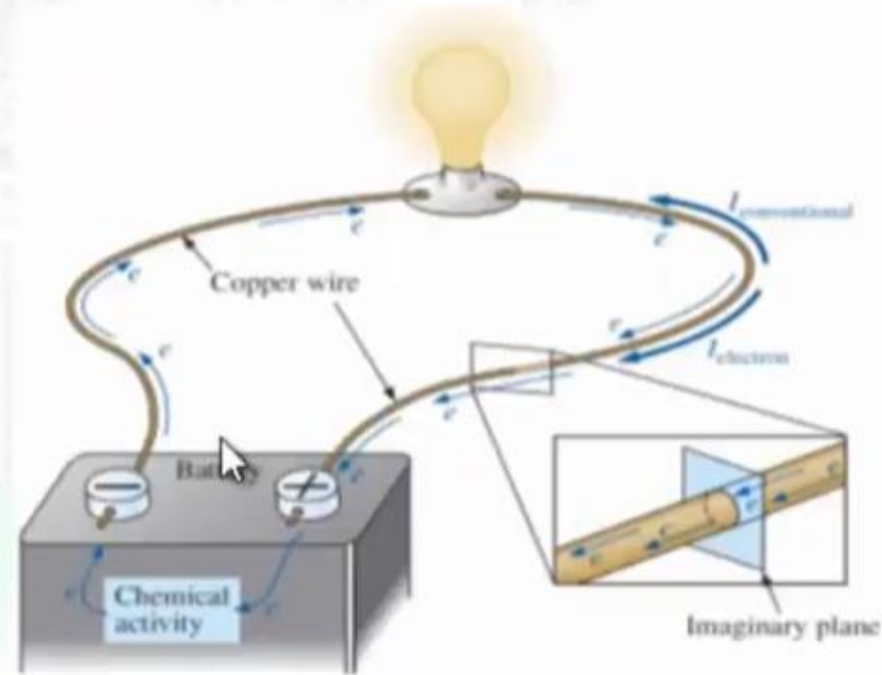
The applied voltage is the starting mechanism the current is a reaction to the applied voltage.



Motion of negatively charged electrons in a copper wire when placed across battery terminals with a difference in potential of volts (V).

Current

If 6.24×10^{18} electrons pass through the imaginary plane in fig 2.6 in 1 second, the flow of charge, or current, is said to be 1 ampere(A)



Basic electric circuit.

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CURRENT

The current in amperes can now be calculated using the following equation:

$$I = \frac{Q}{t}$$

I = amperes (A)

Q = coulombs (C)

t = seconds (s)

The unit of current measurement, **ampere**, was chosen to honor the efforts of André Ampère in the study of electricity in motion.

Examples

CURRENT

EXAMPLE 3 The charge flowing through the imaginary surface in Fig. 9 is 0.16 C every 64 ms. Determine the current in amperes.

Solution: Eq. (5):

$$I = \frac{Q}{t} = \frac{0.16 \text{ C}}{64 \times 10^{-3} \text{ s}} = \frac{160 \times 10^{-3} \text{ C}}{64 \times 10^{-3} \text{ s}} = \mathbf{2.50 \text{ A}}$$

EXAMPLE 4 Determine how long it will take 4×10^{16} electrons to pass through the imaginary surface in Fig. 9 if the current is 5 mA.

Solution: Determine the charge in coulombs:

$$4 \times 10^{16} \text{ electrons} \left(\frac{1 \text{ C}}{6.242 \times 10^{18} \text{ electrons}} \right) = 6.41 \times 10^{-2} \text{ C} \\ = 6.41 \text{ mC}$$

$$\text{Eq. (7): } t = \frac{Q}{I} = \frac{6.41 \times 10^{-2} \text{ C}}{5 \times 10^{-3} \text{ A}} = \mathbf{1.28 \text{ s}}$$

Voltage sources

VOLTAGE SOURCES

The term **dc**, used throughout this text, is an abbreviation for **direct current**, which encompasses all systems where there is a unidirectional (one direction) flow of charge.



Standard symbol for a dc voltage source.

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VOLTAGE SOURCES

In general, DC voltage sources can be divided into three basic types:

- Batteries (chemical action or solar energy)
- Generators (electromechanical)
- Power supplies (rectification a conversion process to be described in your electronics courses).

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Electric Circuits Analysis

VOLTAGE SOURCES

Batteries

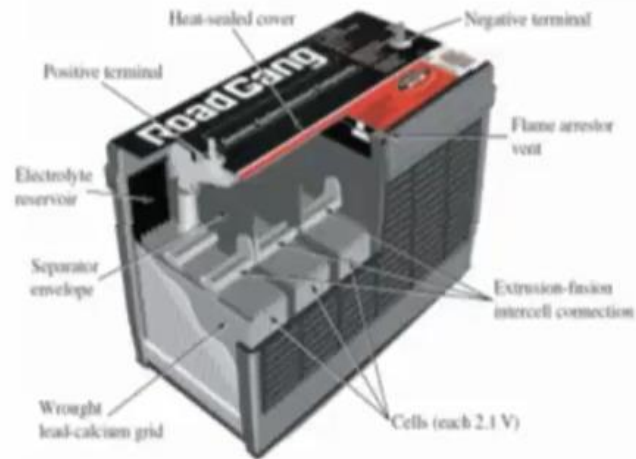


FIG. 2.8: 12 V (actually 12.6 V) lead-acid battery.



FIG. 2.9 Nickel-metal hydride (NiMH) rechargeable batteries.

FIG. 2.10 Lithium primary batteries.



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Electric Circuits Analysis

VOLTAGE SOURCES



FIG. 2.11 Solar System: (a) panels on roof of garage; (b) system operation.

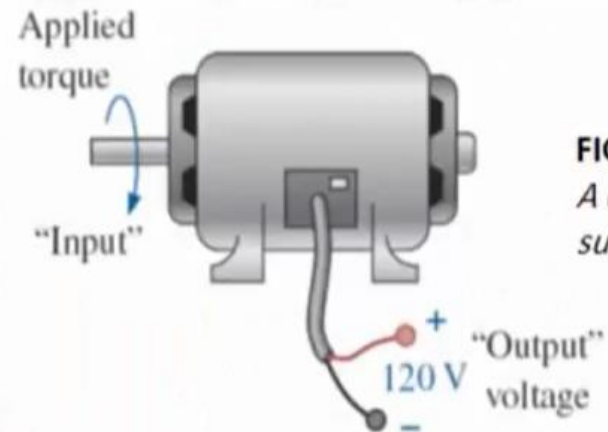


FIG. 2.12 dc generator.



FIG. 2.13 A 0 V to 60 V, 0 to 1.5 A digital display dc power supply

Ammeters and Voltages

AMMETERS AND VOLTMETERS

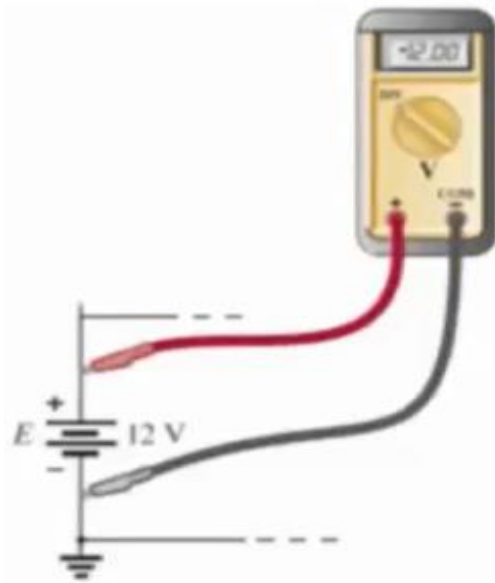


FIG. 2.14 Voltmeter connection for an up-scale (+) reading.

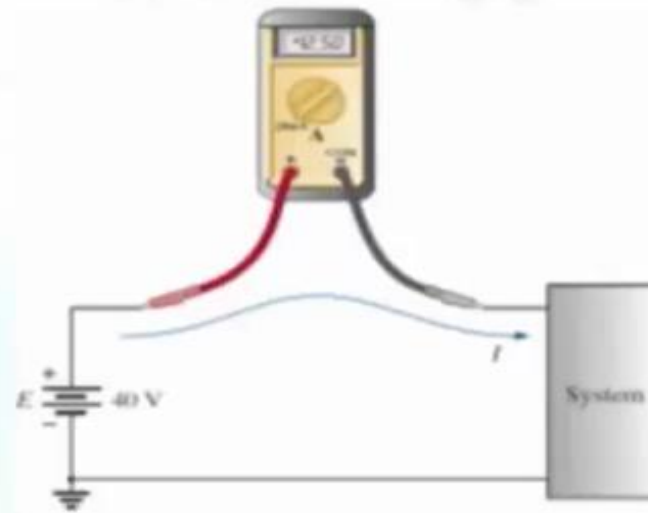


FIG. 2.15 Ammeter connection for an up-scale (+) reading.

Conclusion

VOLTAGE AND CURRENT

Conclusion

In this chapter, the basic impact of current and voltage and the properties of each are introduced and discussed in some detail. Hopefully, any mysteries surrounding the general characteristics of each will be eliminated, and you will gain a clear understanding of the impact of each on an electric/electronics circuit.