Unit-1:ECE131:
Basic Electrical & Electronics Engg

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Using a calculator

- **Addition**: Add 39857 + 19733
- Enter 39857
- then +
- then 19733 and
- then =
- 59590
- Similarly Subtraction, multiplication and division.
- **Find the square root of 35721?**
- Enter 35721
- then √ to get 189

Total Resistance (Parallel Ckt)

- $1/R_T = 1/R_1 + 1/R_2 + 1/R_3 + \ldots\ldots + 1/R_n$
- Reciprocal of R1 (say 15)
- Enter 15 then enter 1/X will give you 1/15= 0.06667
- Similarly for R2, R3 … Rn
- Take total of reciprocals and then 1/X.
- **Calculate total resistance using memory function.**
- For 1/R1, enter 15, then 1/X, then M+ and then C.
- Similarly for R2…Rn.
- Then RM to total of all reciprocals
- Finally take 1/X to get exact value; you may round off of your own.

Safety Precautions

- **General Safety Precautions:**
- Any electrical/electronics circuits should be conducted ensuring following safety procedures;
- Remove power from the circuit or equipment prior to working on it
- Remove and replace fuses only after the power to the circuit has been de-energized.
- Make sure all equipment is properly grounded.
- Use extreme caution when removing or installing batteries containing acid
- In case of an electrical fire, de-energize the circuit and report it immediately to the appropriate authority
- Ensure proper ventilation for locating batteries.

Personal Safety Precautions

- 1. Work only in clean, dry areas.
- 2. Do not wear loose or flapping clothing.
- 3. Wear only nonconductive shoes.
- 4. Remove all rings, wrist-watches, bracelets, ID Chains and tags and other metal items.
- 5. Do not use bare hands to remove hot parts.
- 6. Use a shorting stick to remove high-voltage charges on capacitors.
- 7. Make sure that the equipment is properly grounded.
- 8. Remove power to a circuit before connecting alligator clips.
- 9. When measuring voltage>300V, do not hold test prods.

Fire Safety

- There are three categories of fire, with each requiring special extinguishing techniques;
- **Class A**: Combustible materials such as wood, paper or cloth. Extinguish this type of fire by cooling it with water or smothering it with a CO_2 extinguisher.
- **Class B**: Flammable liquids such as gasoline, kerosene, greases, or solvents. Extinguish by smothering with foam or CO_2 extinguisher.
- **Class C**: Electrical equipment. Extinguish by removing power source and use non-conducting dry power or CO_2 extinguisher.

Electrical Shock

- Electrical shock occurs when an electric current flows through the body when a complete circuit exists.
- Different levels of current produce the following results
- **0.001 Ampere (1mA)** :A mild tingling sensation is felt
- **0.010 A (10mA)** :Start to lose muscular control
- **0.030 A (30mA)** :Breathing becomes upset and labored. Muscular paralysis.
- **0.100 A (100mA)** :Death if current lasts more than 1 second
- **0.200 A (200mA)** : Sever burns, breathing stops; Death

Electrical Shock

- Remember, it is the amount of current flow through the body, not the amount of voltage contacted, that determines the severity of a shock.
- The factors that influence the effects of electrical shock include;
- Intensity of the current: 1mA, 10mA or more
- Frequency of the current: DC or AC
- Current path through the body: if it passes through the chest region, the heart could go into ventricular fibrillation, resulting in rapid & irregular muscular contractions and leading to cardiac arrest and respiratory failure
- Length of the time current passes through the body.

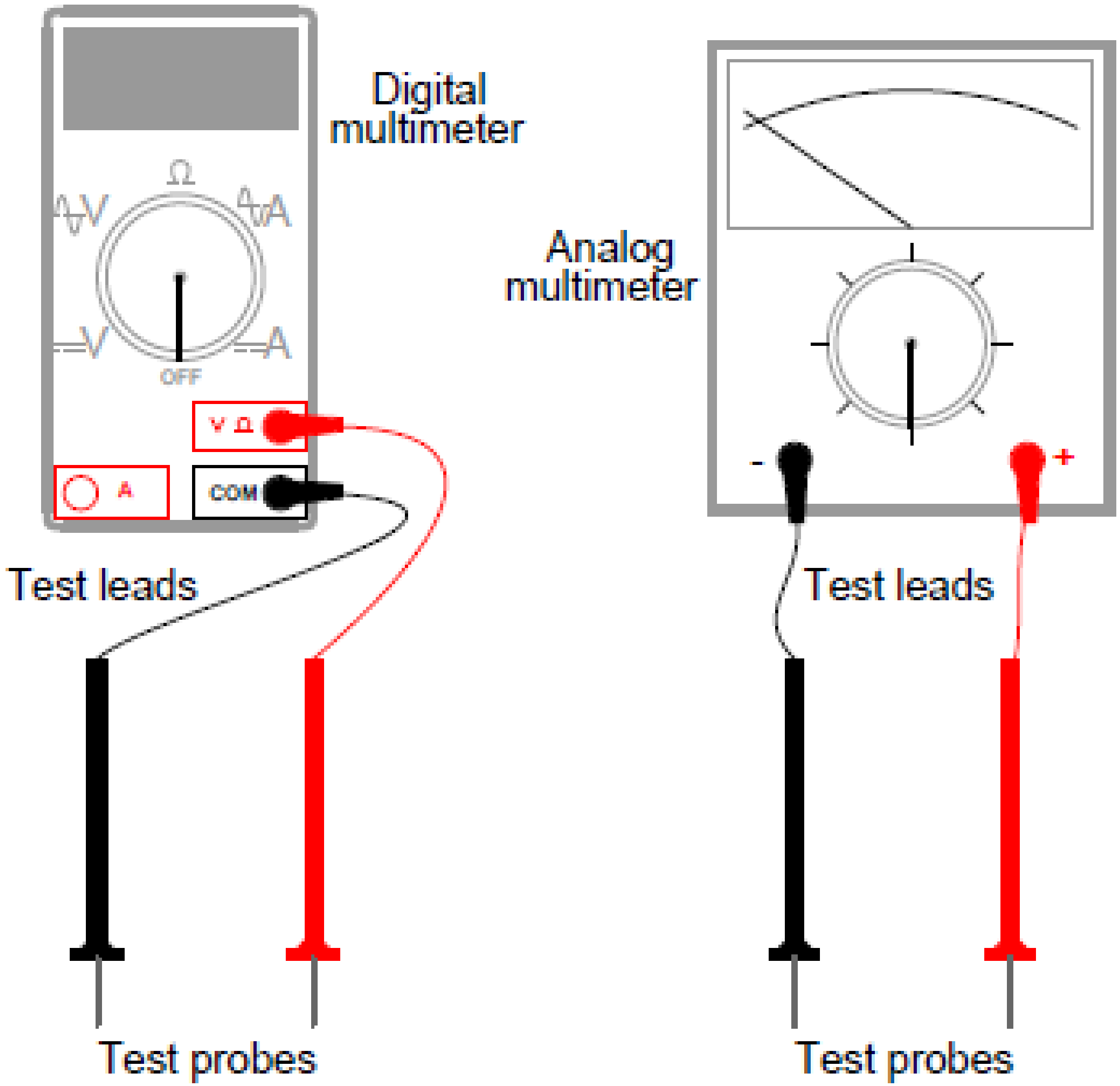
Electrostatic Discharges

- Static electricity is an electrical charge at rest on a surface.
- A surface can become charged through **three** means.
- **Rubbing two dissimilar materials together will generate an electrical charge**. Walking across floor or removing a garment will develop a voltage > 5000V
- **Induction** is second means of developing a charge. Handling a PCB or electronic component wrapped in plastic material induces a charge into contents of plastic wrap, resulting into ESD damage if handled by other person.
- **Capacitance** is the third means of generating a static charge.
- **Metal Oxide Semiconductors (MOS) are extremely sensitive to static charges**

ESD Prevention

- Manufacturers have designed protective circuitry to help dissipate ESD using zener diodes and limiting resistors.
- Practice following procedures to prevent ESD damage;
- 1. Treat all components and circuits as static sensitive.
- 2. Do not touch the leads, pins or components of PCB traces.
- 3. Before handling a component or circuit, discharge yourself by touching a grounded metal surface.
- 4. Keep components in original packing until needed.
- 5. Never slide static components over any surface

Multi-meters



Unit-1: DC Circuits

- **GOAL**
  - This module introduces the student to the theory and applications of DC circuits through manipulative experiences. The student will also develop an awareness of the skills required in the field of electronics.
- **TOPICS**
- *Teaching Time:*
  - 1. Fundamentals of Electricity
  - 2. Current
  - 3. Voltage
  - 4. Resistance
  - 5. Ohm's Law
  - 6. Electrical Measurements - Meters
  - 7. Power
  - 8. DC Circuits
  - 9. Magnetism
  - 10. Inductance
  - 11. Capacitance

SKILLS, KNOWLEDGE, AND BEHAVIORS TO BE DEVELOPED

- The student should be able to:
- 1. Explain the relationship between current, voltage, resistance, and power.
- 2. Solve basic electronic problems involving current, voltage, and resistance.
- 3. Use a multi-meter to measure current, voltage, and resistance.
- 4. Convert from one prefix to another and work with powers of ten.
- 5. Explain the operation and purpose of various electronic components.
- 6. Discuss the relationship between electricity and magnetism.
- 7. Demonstrate proper safety practices when working on lab experiments
- and projects.
- 8. Construct and experiment with basic DC electronic circuits using schematic diagrams

Chapter 1

Fundamentals of Electricity

Objectives

- After completing this chapter, you will be able to:
  - Define *atom, matter, element,* and *molecule*
  - List the parts of an atom
  - Define the *valence shell* of an atom
  - Identify the unit for measuring current
  - Draw the symbol used to represent current flow in a circuit

Objectives

- Describe the difference between conductors, insulators, and semiconductors
- Define *difference of potential*, *electromotive force*, and *voltage*
- Draw the symbol used to represent voltage
- Identify the unit used to measure voltage
- Define *resistance*

Objectives

- Identify characteristics of resistance in a circuit
- Identify the unit for measuring resistance
- Draw the symbol used to represent resistance in a circuit

Matter, Elements, and Compounds

- Matter
  - Anything that occupies space
  - Can be an element or compound
- Element
  - Basic building block of nature
- Compound
  - Chemical combination of two or more elements

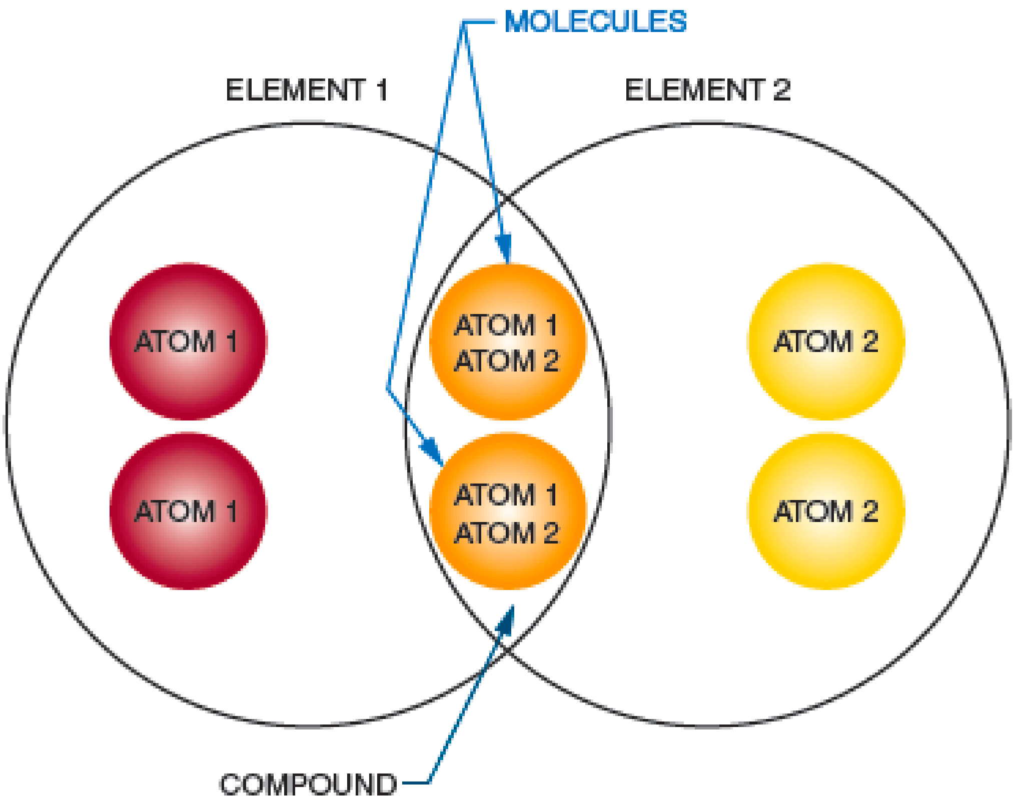


Figure 1-1. The chemical combination of two or more elements is called a compound. A molecule is the chemical combination of two or more atoms. Examples are water (H_2O) and salt (NaCl).

Matter, Elements, and Compounds (cont'd.)

- Atom
  - Smallest particle of an element
- Molecule
  - Chemical combination of two or more atoms
  - Smallest part of a compound
- Mixture
  - Physical combination of elements and compounds

A Closer Look at Atoms

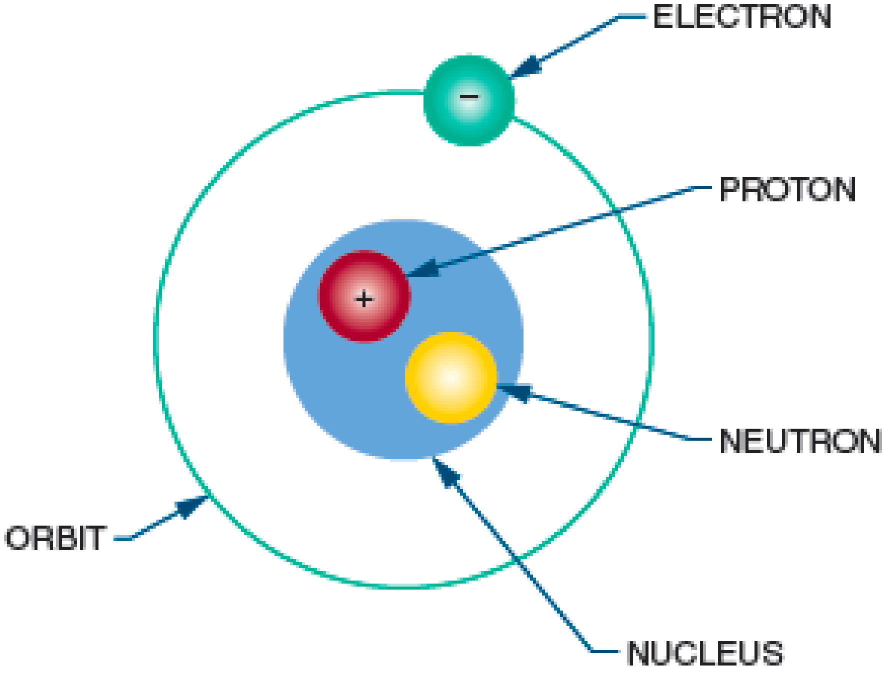


Figure 1-2. Parts of an atom.

A Closer Look at Atoms (cont’d.)

- Atomic number
  - Distinguishes one element from another
  - Number of protons in the nucleus
- Atomic weight
  - Mass of the atom
  - Sum of protons and neutrons

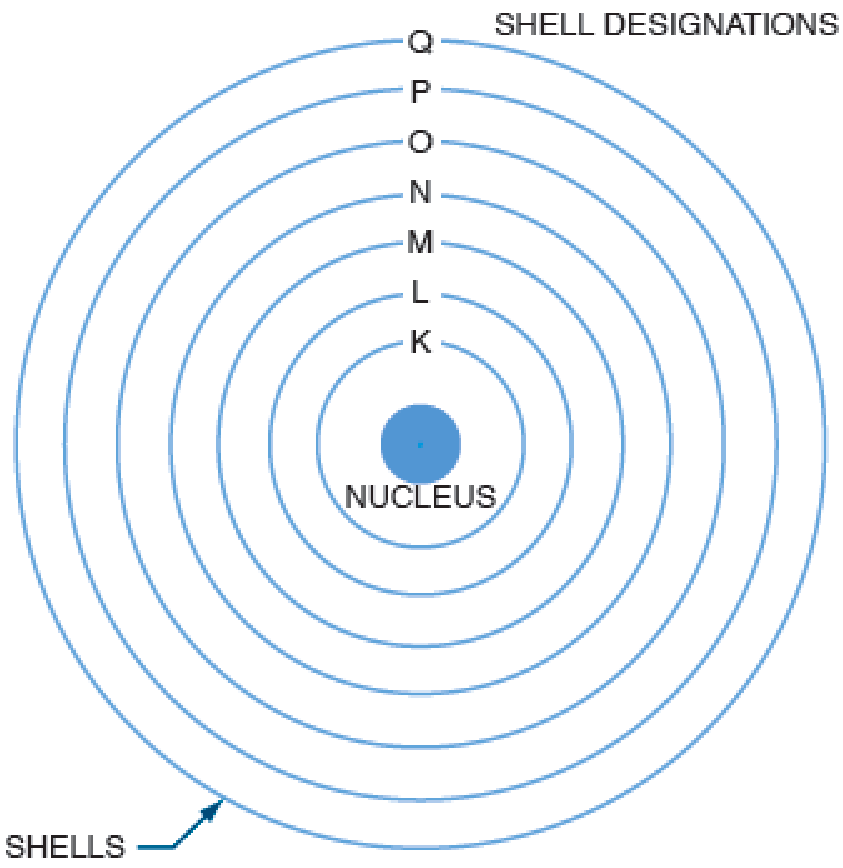


Figure 1-3. The electrons are held in shells around the nucleus.

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A Closer Look at Atoms (cont'd.)

- Valence shell
  - Outer shell of an atom
- Conductors
  - Contain a large number of free electrons
- Insulators
  - Prevent the flow of electricity
  - Absorb valence electrons from other atoms

A Closer Look at Atoms (cont'd.)

- Semiconductors
  - Can function as conductors or insulators
- Ionization
  - Process of gaining or losing electrons

Current

- Current (I)
  - Flow of electrons from negatively charged atoms to positively charged atoms
  - Measured in amperes (A)
- Coulomb (C)
  - Charge of 6.24×10^{18} electrons

Voltage

- Potential
  - Ability of source to perform electrical work
- Difference of potential
  - Referred to as electromotive force (emf) or voltage
- Voltage (E)
  - Force that moves electrons in a circuit
  - Measured in volts (V)

Voltage (cont'd.)

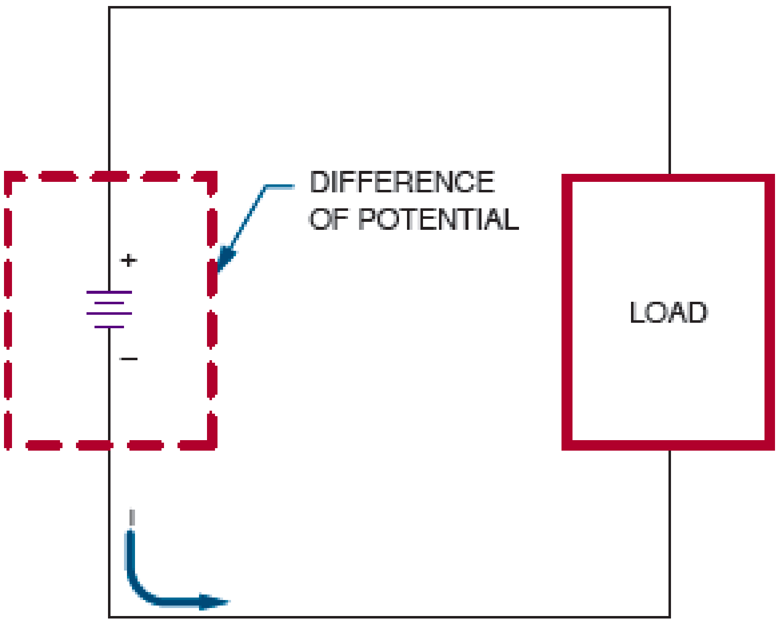


Figure 1-8. Electrons flow in a circuit because of the difference of potential.

Resistance

- Resistance (R)
  - Opposition to current
  - Measured in ohms (Ω)
- Conductors
  - Low resistance; possess many free electrons
- Insulators
  - High resistance; have few free electrons

Summary

- Matter can be an element or a compound
- The atom consists of protons, neutrons, and electrons
- Key electronic concepts in this chapter:
  - Ionization, current, voltage, resistance, conductors, insulators

Summary

- The flow of electrons is called current
- Current can encounter opposition, called resistance

Chapter 2

Current

Objectives

- After completing this chapter, you will be able to:
  - State the two laws of electrostatic charges
  - Define *coulomb*
  - Identify the unit used to measure current flow
  - Define the relationship of amperes, coulombs, and time through a formula
  - Describe how current flows in a circuit

Objectives (cont'd.)

– Describe how electrons travel in a conductor
– Define and use *scientific notation*
– Identify commonly used prefixes for powers of ten

Electrical Charge

- First law of electrostatic charges
  - Like charges repel
- Second law of electrostatic charges
  - Unlike charges attract
- Coulomb (C)
  - Unit for measuring electrical charge (Q)
  - 1 C = 6.24×10^{18} electrons

Electrical Charge (cont'd.)

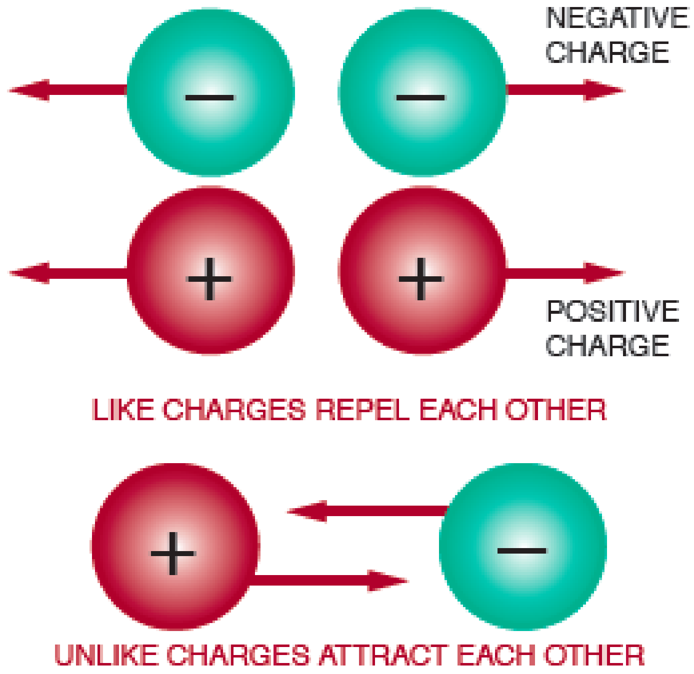


Figure 2-1. Basic laws of electrostatic charges.

Current Flow

- Electric current
  - Drift of electrons from the negative area to the positive
- Ampere (A)
  - Unit of measurement for current flow
- $I = Q/t$, where:

  I = current measured in amperes

  Q = quantity of electrical charge in coulombs

  t = time in seconds

Current Flow (cont'd.)

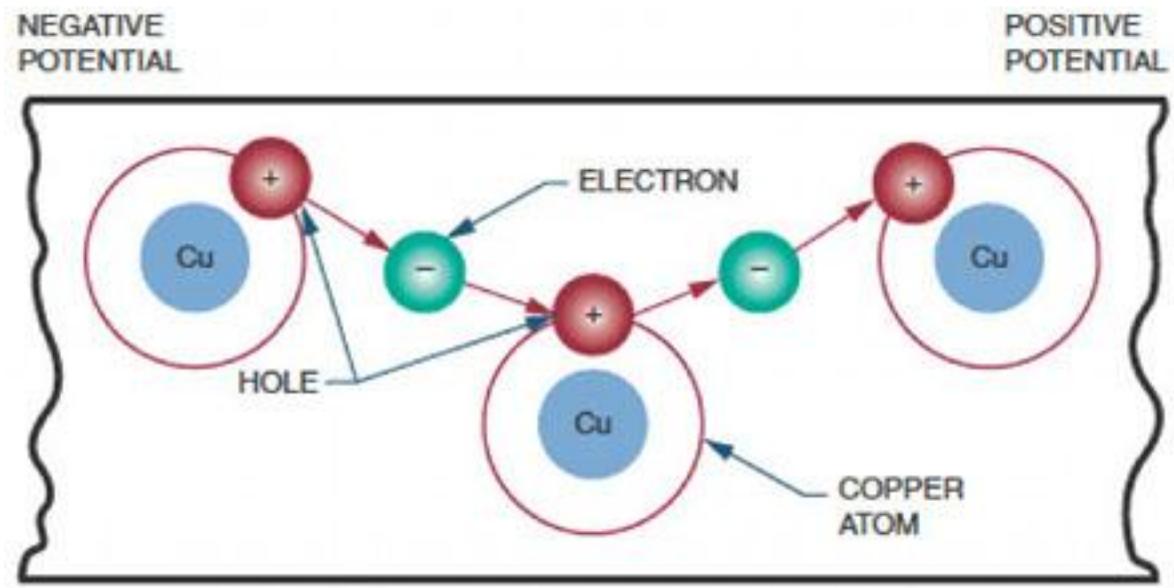


Figure 2-2. As electrons move from one atom to another, they create the appearance of a positive charge, called a hole.

Current Flow (cont'd.)

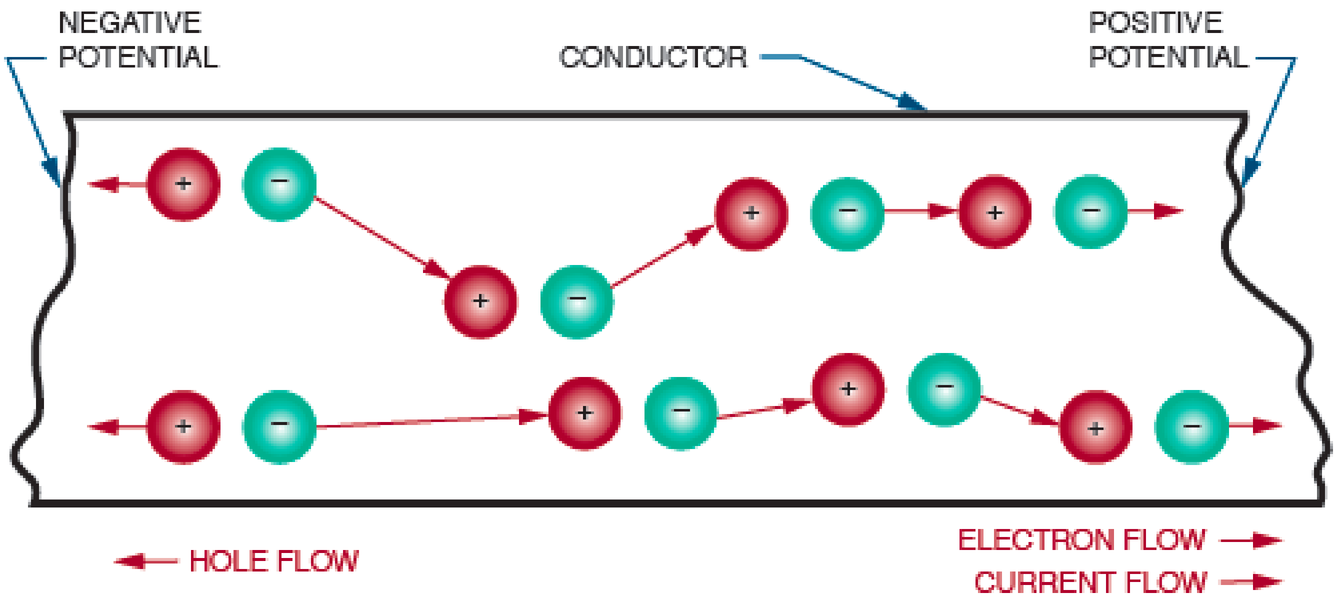


Figure 2-3. Electron movement occurs in the opposite direction to hole movement.

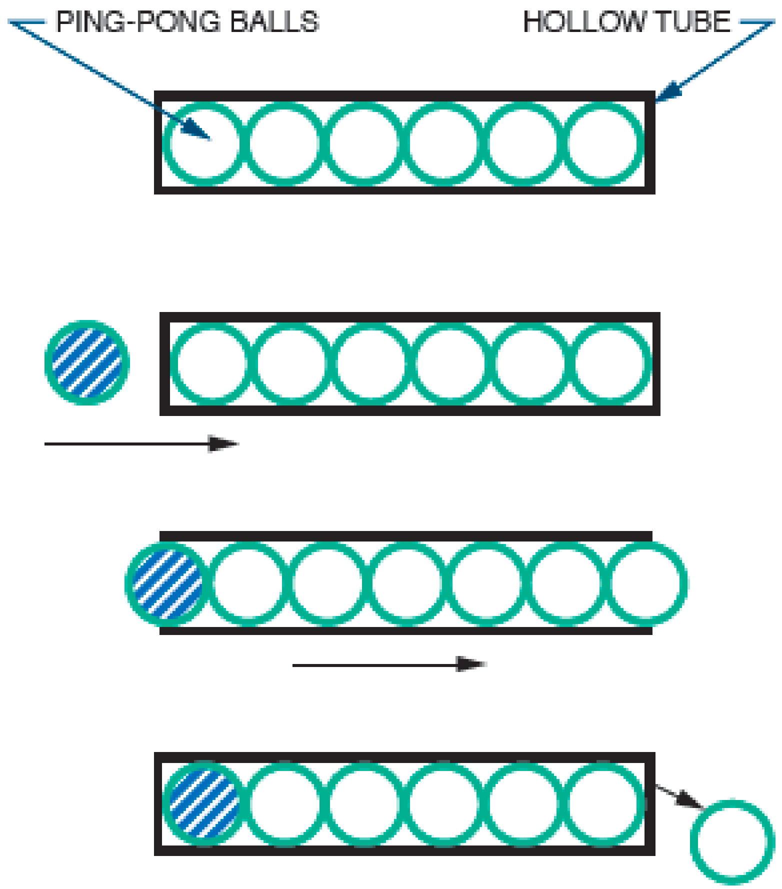
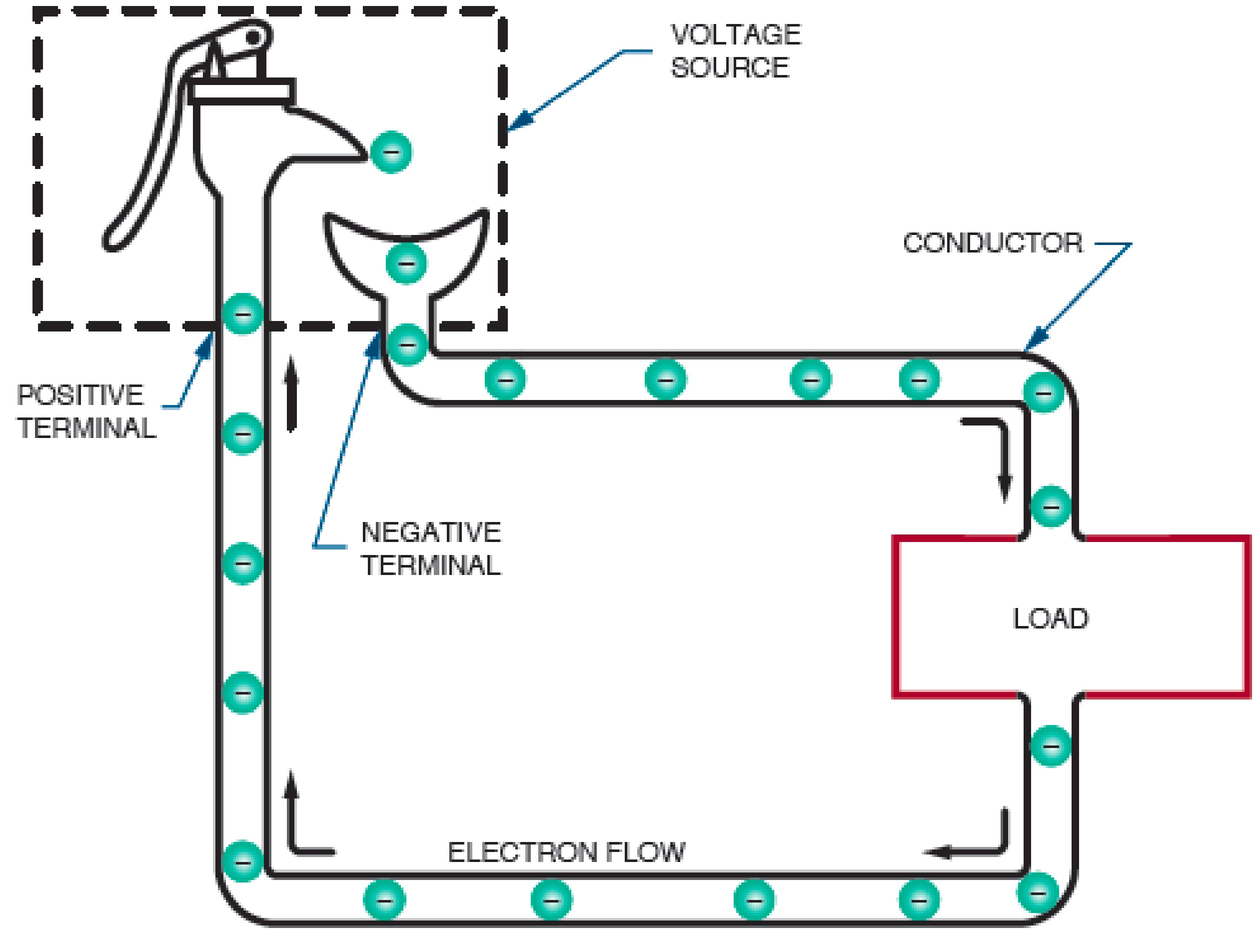


Figure 2-4. Electrons in a conductor react like Ping-Pong balls in a hollow tube.



on

Figure 2-5. A voltage source can be considered a pump that supplies electrons to the load and recycles the excess electrons.

Scientific Notation

- Scientific notation
  - Means to express large and small numbers in shorthand
  - Uses single-digit numbers plus powers of ten
- Positive exponent

  $3 \times 10^3 = 3.0 \times 10^3 = 3000$
- Negative exponent

  $3 \times 10^{-6} = 3.0 \times 10^{-6} = 0.000003$

Scientific Notation (cont'd.)

PREFIX	SYMBOL	VALUE	DECIMAL VALUE
Tetra-	T	10^{12}	1,000,000,000,000
Giga-	G	10^{9}	1,000,000,000
Mega-	M	10^{6}	1,000,000
Kilo-	k	10^{3}	1,000
Milli-	m	10^{-3}	0.001
Micro-	μ	10^{-6}	0.000001
Nano-	n	10^{-9}	0.000000001
Pico-	p	10^{-12}	0.000000000001

Figure 2-6. Prefixes commonly used in electronics.

Summary

- Two laws of electrostatic charges: like charges repel, unlike charges attract
- Electrons break free from atoms to produce current flow
- $I = Q/t$
- Hole movement occurs in the opposite direction to electron movement

Summary (cont'd.)

- Current flow in a circuit is from negative to positive
- Electrons travel slowly, but individual electrons move at the speed of light
- Key concepts in this chapter:
  - Coulumb, ampere, scientific notation

Chapter 3

Voltage

Objectives

- After completing this chapter, you will be able to:
  - Identify the six most common voltage sources
  - Describe six different methods of producing electricity
  - Define a cell and a battery
  - Describe the difference between primary and secondary cells

Objectives (cont'd.)

- Describe how cells and batteries are rated
- Identify ways to connect cells or batteries to increase current or voltage output or both
- Define *voltage rise* and *voltage drop*
- Identify the two types of grounds associated with electrical circuits

Voltage Sources

- Six common voltage sources:
  - Friction, magnetism, chemicals, light, heat, and pressure
- Friction
  - Oldest known method of producing electricity
  - Example: Van de Graaf generator

Voltage Sources (cont'd.)

- Magnetism
  - Most common method used today
  - Example: generator
- Chemical cell
  - Second most common method used today
  - Contains positive and negative electrodes separated by an electrolytic solution

Voltage Sources (cont'd.)

Figure 3-6. A photovoltaic cell can convert sunlight directly into electricity.

Voltage Sources (cont'd.)

Figure 3-8. Thermocouples convert heat energy directly into electrical energy.

Cells and Batteries

- Battery
  - Combination of two or more cells
- Primary cells
  - Cannot be recharged
  - Example: dry cells
- Secondary cells
  - Can be recharged
  - Example: lead-acid batteries

Connecting Cells and Batteries

- Series-aiding configuration
  - Output current is the same

    $I_T = I_1 = I_2 = I_3$
  - Output voltage increases

    $E_T = E_1 + E_2 + E_3$

Connecting Cells and Batteries (cont'd.)

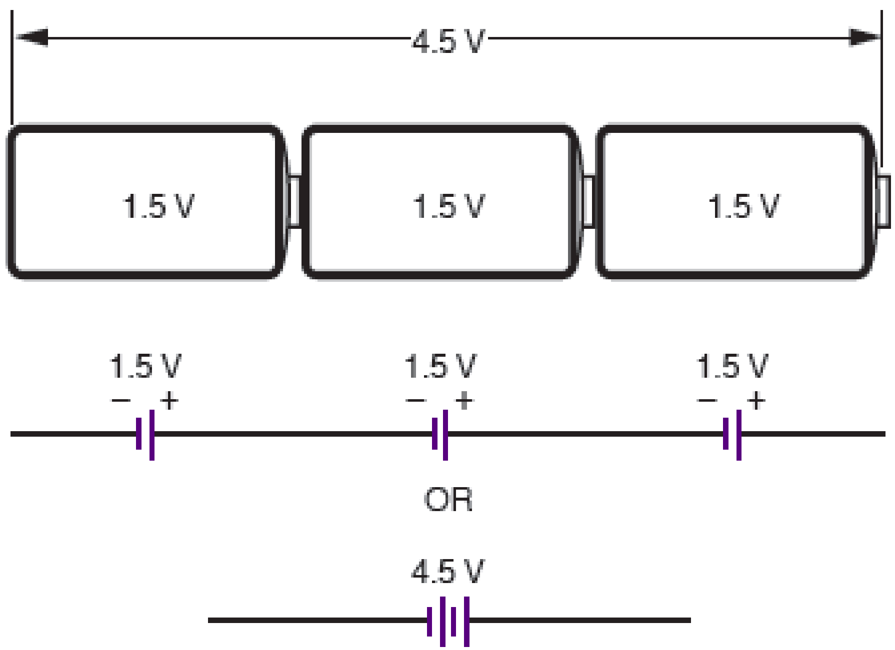


Figure 3-18. Cells or batteries can be connected in series to increase voltage.

Connecting Cells and Batteries (cont'd.)

- Parallel configuration
  - Output current increases

    $I_T = I_1 + I_2 + I_3$
  - Voltage output remains the same

    $E_T = E_1 = E_2 = E_3$

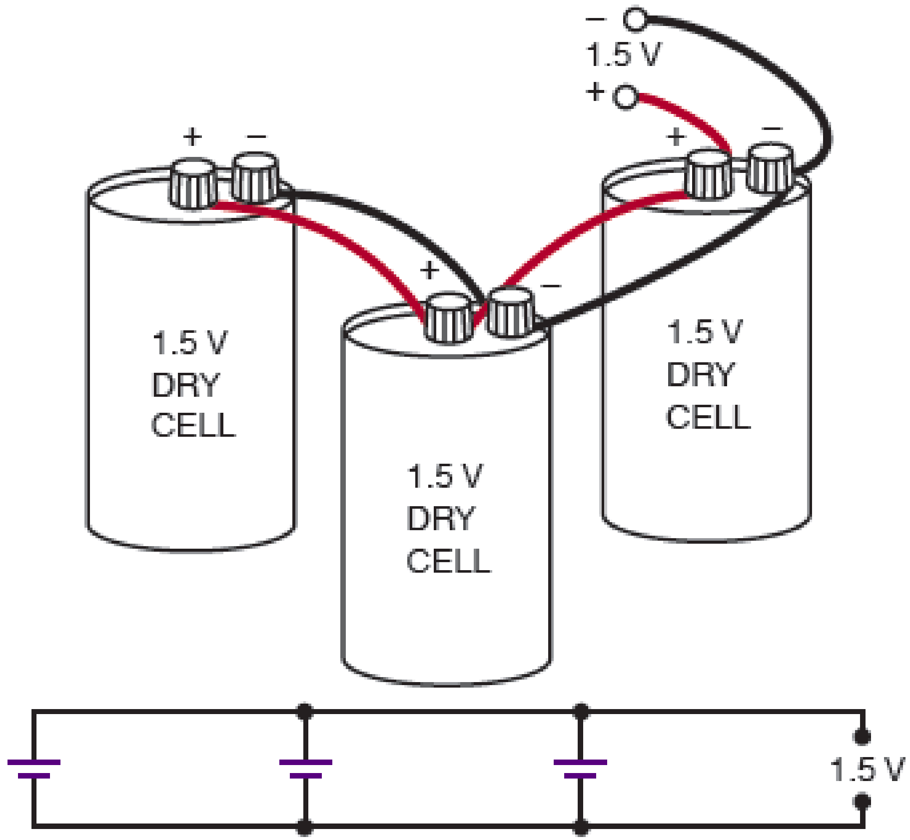


Figure 3-19. Cells or batteries can be connected in parallel to increase current flow.

Connecting Cells and Batteries (cont'd.)

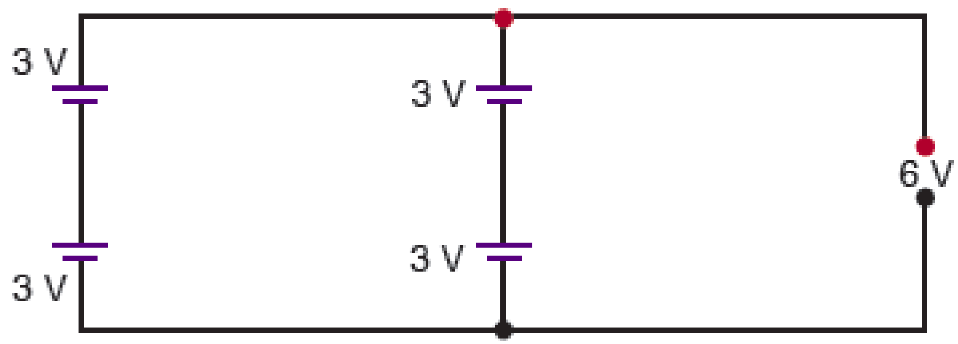


Figure 3-20. Cells and batteries can be connected in series-parallel to increase current and voltage outputs.

Connecting Cells and Batteries (cont'd.)

Figure 3-21. The voltage increases when cells are connected in series.

Connecting Cells and Batteries (cont'd.)

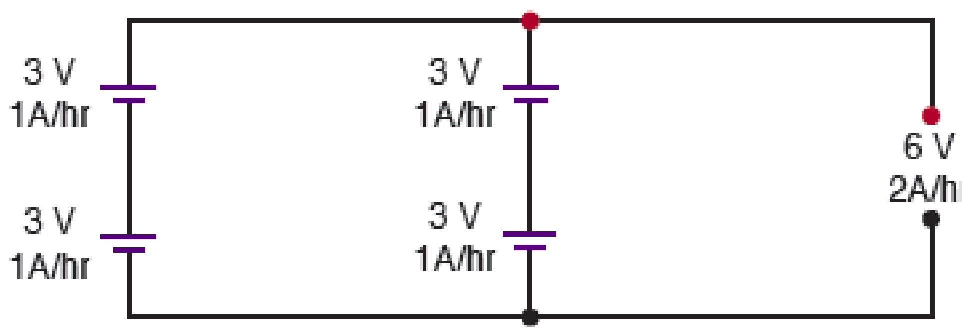


Figure 3-22. Connecting the series-connected cells in parallel increases the output current. The net result is a series-parallel configuration.

Voltage Rises and Voltage Drops

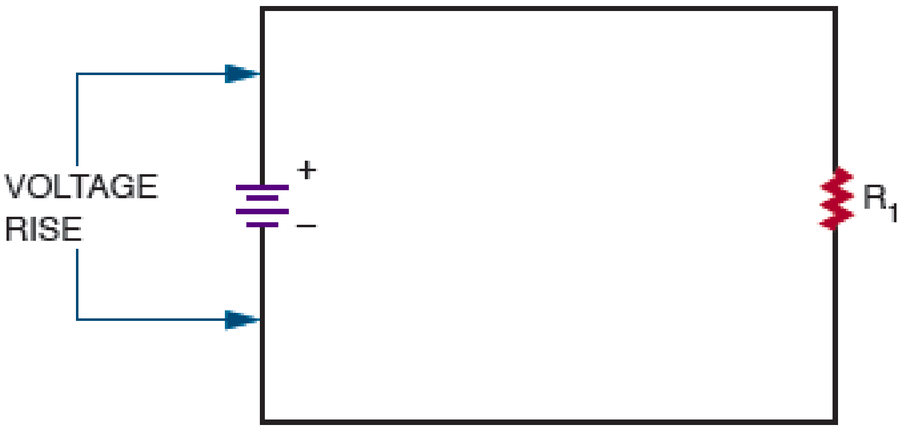


Figure 3-23. A potential applied to a circuit is called a voltage rise.

Voltage Rises and Voltage Drops (cont'd.)

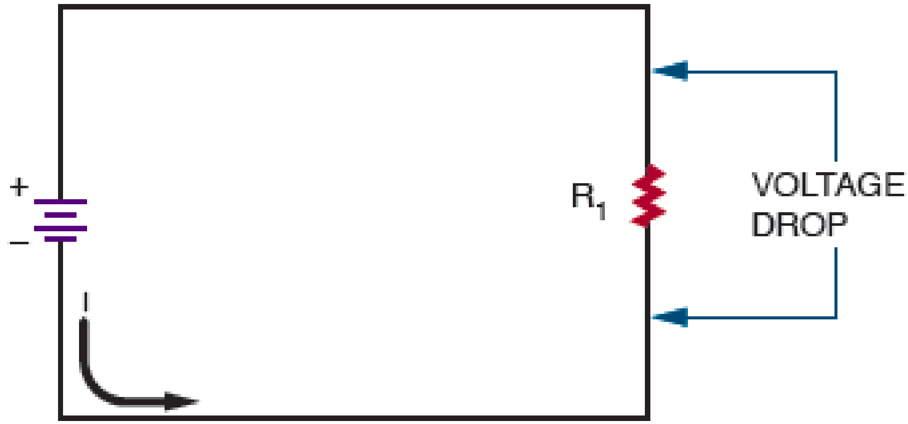


Figure 3-24. The energy used by the circuit in passing current through the load (resistance) is called a voltage drop. A voltage drop occurs when current flows in the circuit.

Ground as a Voltage Reference Level

- Ground
  - Term used to identify zero potential
- Earth grounding
  - Keeps appliances and equipment at same potential
- Electrical grounding
  - Provides common reference point

Summary

- Current is produced when an electron is forced from its orbit
- Voltage provides energy to dislodge electrons from their orbit
- A voltage source provides a means of converting some other form of energy into electrical energy

Summary (cont'd.)

- Cells and batteries can be connected in series, in parallel, or in series-parallel to increase voltage, current, or both
- Key concepts in this chapter:
  - Primary cells, secondary cells, ampere-hours, voltage rise, voltage drop, Ground

Chapter 4

Resistance

Objectives

- After completing this chapter, you will be able to:
  - Define *resistance* and explain its effect in a circuit
  - Determine the tolerance range of a resistor
  - Identify carbon composition, wirewound, and film resistors
  - Identify potentiometers and rheostats

Objectives (cont'd.)

- Describe how a variable resistor operates
- Decode a resistor's value using the color code or alphanumeric code
- Identify the three types of resistor circuits
- Calculate total resistance in series, parallel, and series-parallel circuits

Resistance

CONDUCTOR MATERIAL	RESISTIVITY
Silver	1.000
Copper	1.0625
Lead	1.3750
Gold	1.5000
Aluminum	1.6875
Iron	6.2500
Platinum	6.2500

Figure 4-1. Resistance of several conductors of the same length and cross-section area.

Conductance

- Conductance (G)
  - Ability of a material to pass electrons
  - Unit of conductance is Mho
  - Measured in Siemens (S)

Resistors

- Resistors
  - Possess a specific value of resistance to current flow
  - Either fixed or variable
  - Resistor’s tolerance
    - Amount the resistor can vary and still be acceptable
    - 10% tolerance is satisfactory

Resistors (cont’d.)

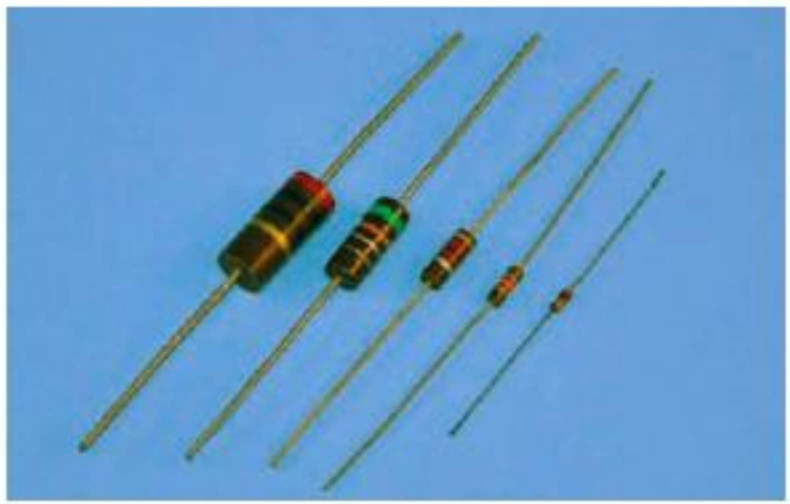


Figure 4-6. Carbon composition resistors were the most widely used resistors in electronic circuits.

Resistors (cont'd.)

Figure 4-7. Wirewound resistors are available in many different styles.

Resistors (cont'd.)

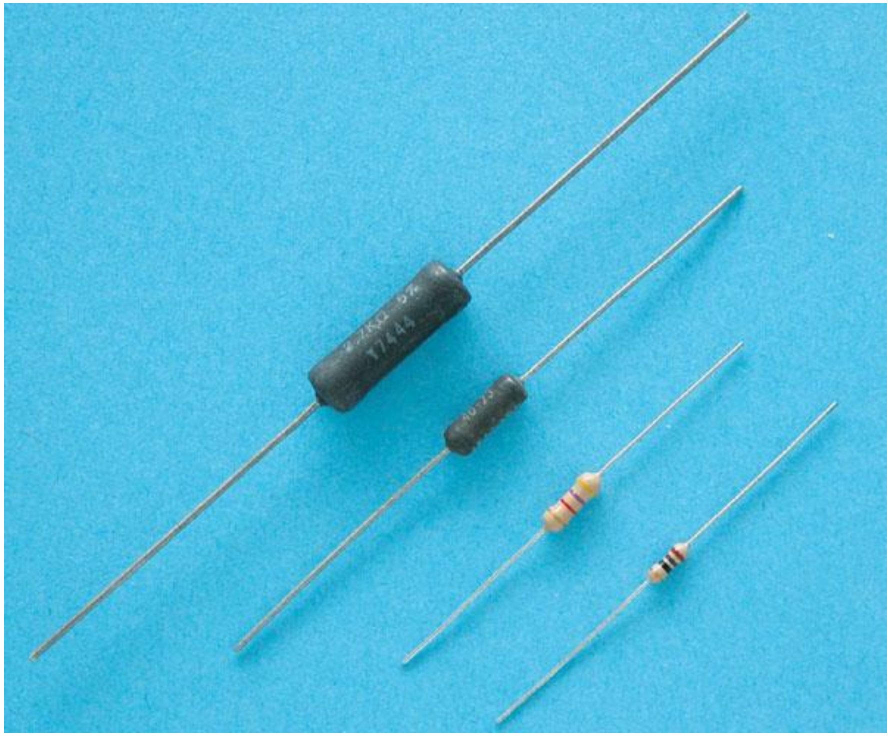


Figure 4-8. The film resistor offers the size of the carbon resistor with the accuracy of the wirewound resistor.

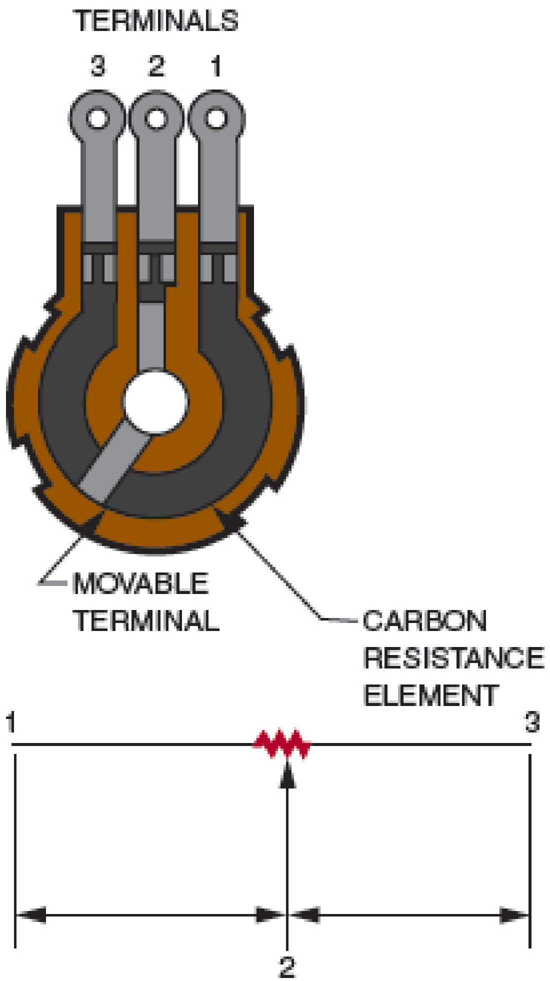
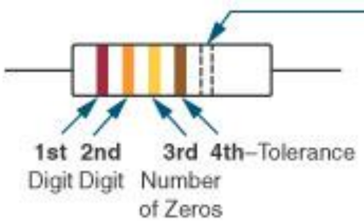


Figure 4-10. Variable resistors allow the resistance to increase or decrease at random.

Resistors (cont'd.)

- Potentiometer (or *pot*)
  - A variable resistor used to control voltage
- Rheostat
  - A variable resistor used to control current



Two-Significant-Figure Color Code

	1ST BAND 1ST DIGIT	2ND BAND 2ND DIGIT	3RD BAND NUMBER OF ZEROS	4TH BAND TOLERANCE
Black	0	0	—	—
Brown	1	1	0	1%
Red	2	2	00	2%
Orange	3	3	000	—
Yellow	4	4	0,000	—
Green	5	5	00,000	0.5%
Blue	6	6	000,000	0.25%
Violet	7	7		0.10%
Gray	8	8		0.05%
White	9	9		—
Gold			×0.1	5%
Silver			×0.01	10%
No Color				20%

Figure 4-12. The Electronic Industries Association (EIA) color code.

Resistor Identification (cont'd.)

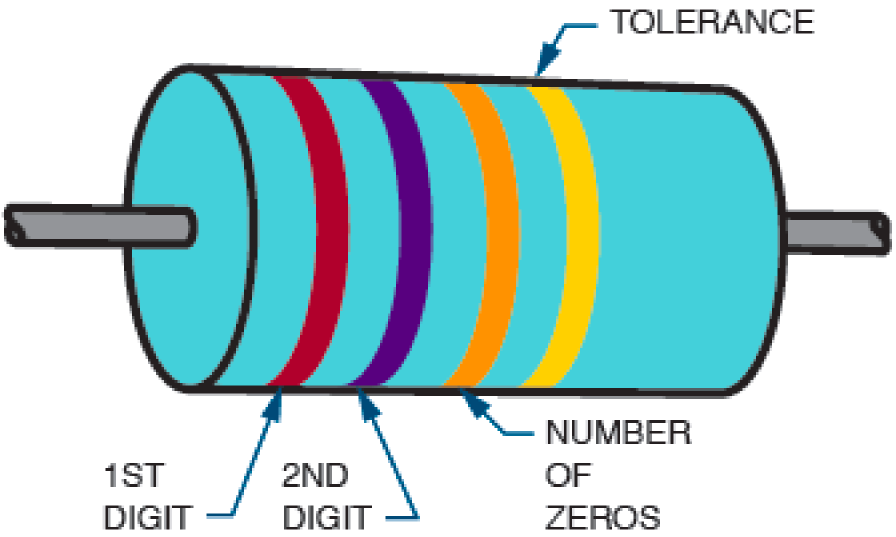


Figure 4-13. Meaning of the colored bands on a carbon composition resistor.

Resistor Identification (cont'd.)

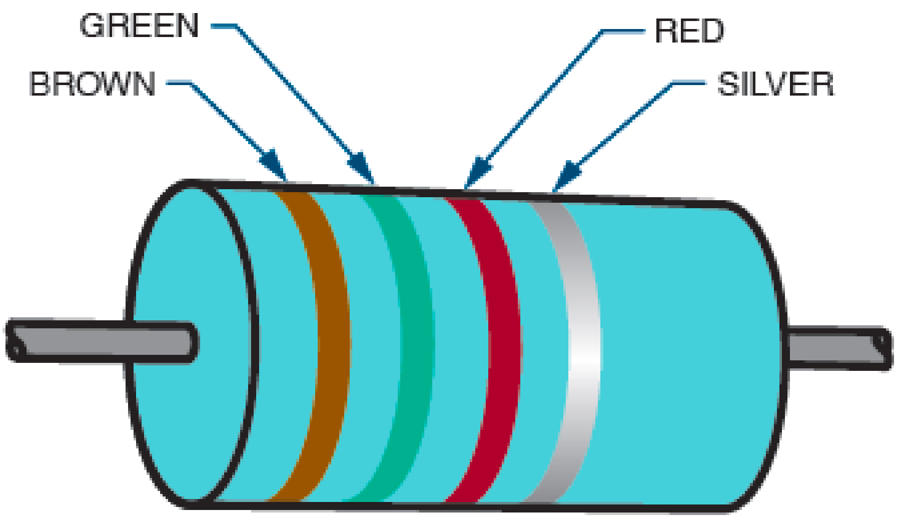


Figure 4-14. This resistor has a resistance value of 1500 ohms.

Resistor Identification (cont'd.)

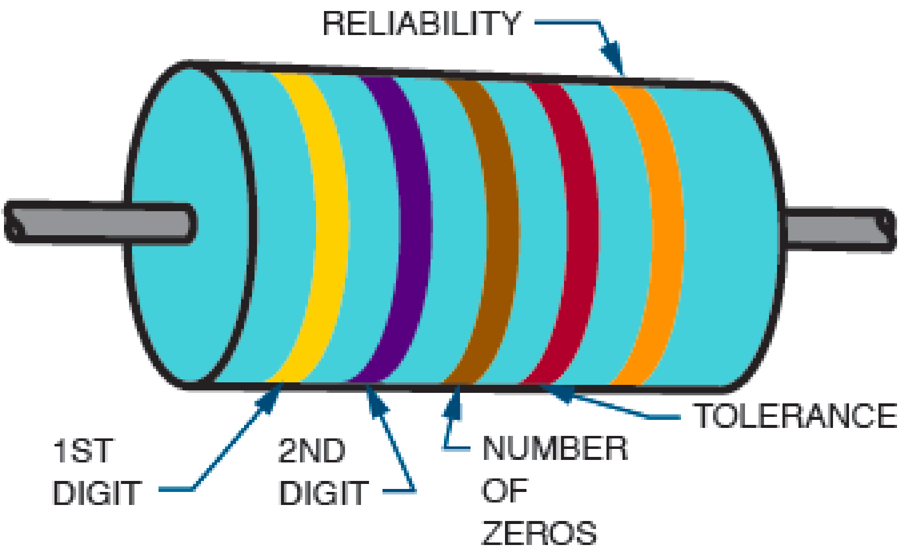


Figure 4-15. The fifth band on a resistor indicates the resistor's reliability.

Resistor Identification (cont'd.)

Figure 4-16. Resistors may also be identified by a letter-and-number system.

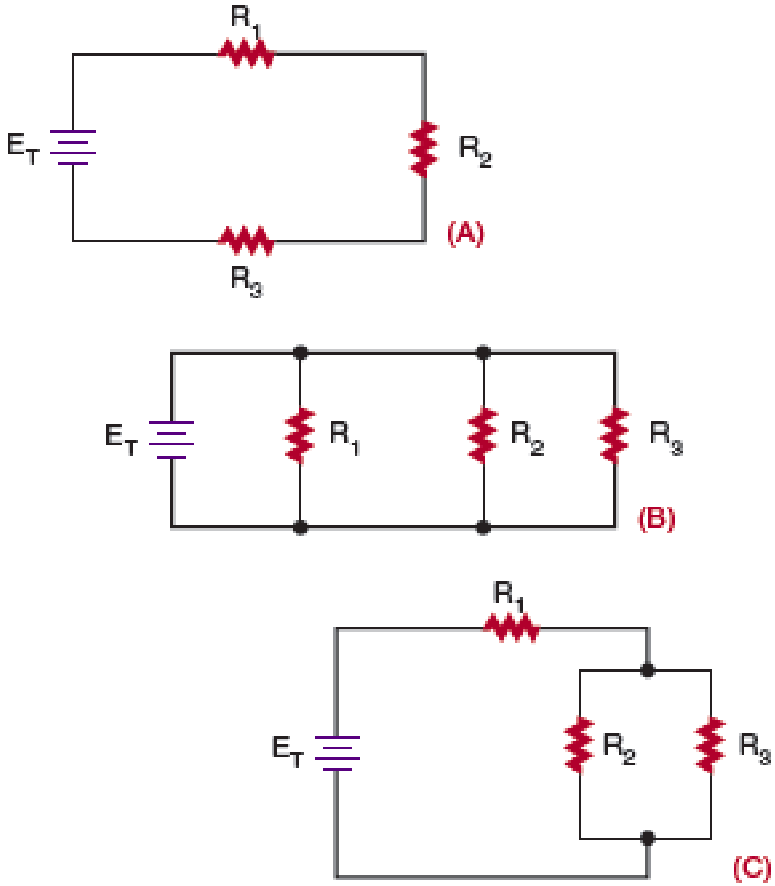


Figure 4-18. Three types of resistive circuits: (A) series circuit, (B) parallel circuit, (C) series-parallel circuit.

Connecting Resistors in Series

- Series circuit
  - Provides one path for current to flow
  - Total resistance formula:

    $R_T = R_1 + R_2 + R_3 \ldots + R_n$

Connecting Resistors in Parallel

- Parallel circuit
  - Provides two or more paths for current to flow
  - Total resistance formula:

    $1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \ldots + 1/R_n$
  - Total resistance is always less than smallest resistor

Connecting Resistors in Series and Parallel

- Series-parallel circuit
  - Combination of a series and a parallel circuit
  - To calculate total resistance, use the series and parallel formulas

Summary

- Resistance is opposition to flow of current
- Several factors, such as size and type of wire, affect electrical resistance
- Resistors are either fixed or variable
- Three major categories of resistors: molded carbon composition, wirewound, or film

Summary (cont'd.)

- Variable resistors allow resistance to vary
- Resistor values may be identified by colored bands or by an alphanumeric system
- Three types of resistive circuits: series, parallel, series-parallel

Chapter 5

Ohm's Law

Objectives

- After completing this chapter, you will be able to:
  - Identify the three basic parts of a circuit
  - Identify three types of circuit configurations
  - Describe how current flow can be varied in a circuit
  - State Ohm's law with reference to current, voltage, and resistance

Objectives (cont'd.)

– Solve problems using Ohm's law for current, resistance, or voltage in series, parallel, and series-parallel circuits
– Describe how the total current flow differs between series and parallel circuits
– Describe how the total voltage drop differs between series and parallel circuits
– Describe how the total resistance differs between series and parallel circuits

Objectives (cont'd.)

- State and apply Kirchhoff's current and voltage laws
- Verify answers using Ohm's law with Kirchhoff's law

Electric Circuits

- Electric circuit
  - Path that current follows
    - Series circuit, parallel circuit, or series-parallel circuit
  - Consists of a voltage source, load, and a conductor

Electric Circuits (cont'd.)

Figure 5-4. Current flow in an electric circuit flows from the negative side of the voltage source, through the load, and returns to the voltage source through the positive terminal.

Electric Circuits (cont'd.)

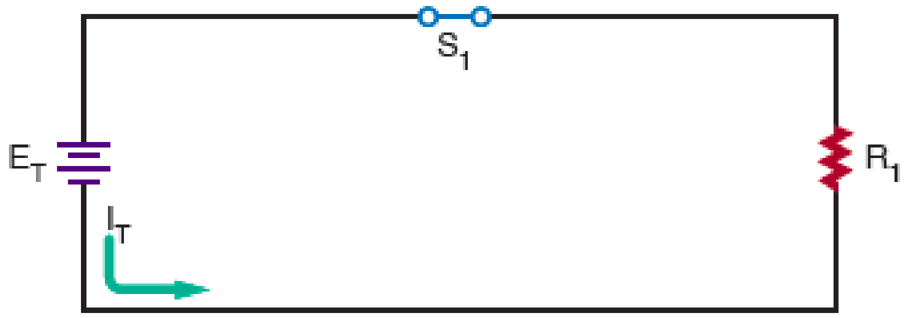


Figure 5-5. A closed circuit supports current flow.

Electric Circuits (cont'd.)

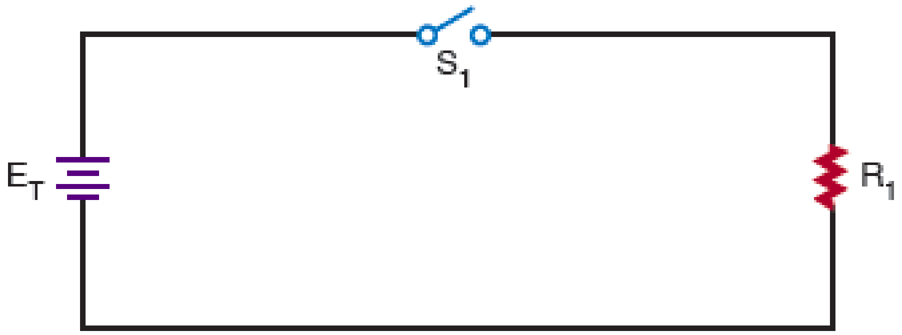


Figure 5-6. An open circuit does not support current flow.

Electric Circuits (cont'd.)

Figure 5-7. Current flow in an electric circuit can be changed by varying the voltage.

Electric Circuits (cont'd.)

Figure 5-8. Current flow in an electric circuit can also be changed by varying the resistance in the circuit.

Ohm’s Law

- Ohm’s Law
  - Current is directly proportional to voltage and inversely proportional to resistance
  - May be expressed as:

$$I = E/R$$

where: I = current in amperes

E = voltage in volts

R = resistance in ohms

Application of Ohm's Law

- In a series circuit:

$$I_T = I_{R_1} = I_{R_2} = I_{R_3} \ldots = I_{R_n}$$

$$E_T = E_{R_1} + E_{R_2} + E_{R_3} \ldots + E_{R_n}$$

$$R_T = R_1 + R_2 + R_3 \ldots + R_n$$

Application of Ohm’s Law (cont’d.)

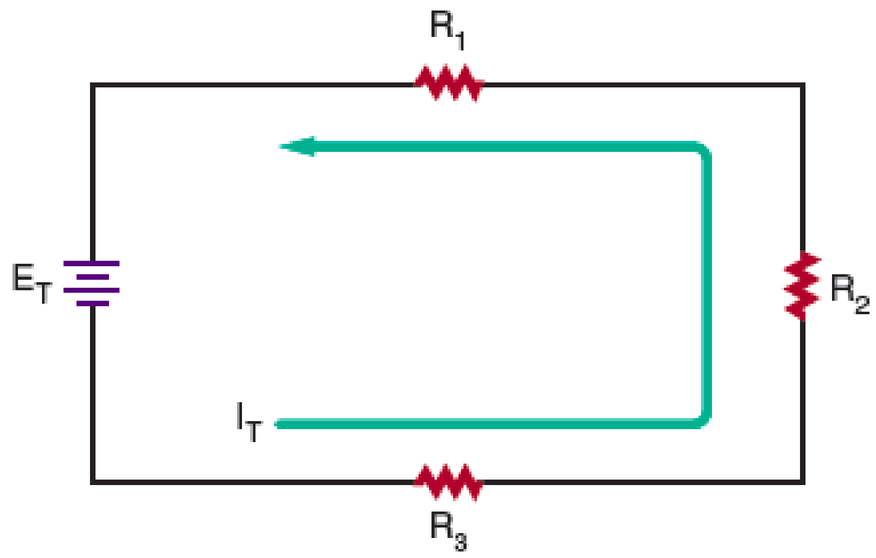


Figure 5-12. In a series circuit, the current flow is the same throughout the circuit.

Application of Ohm's Law (cont'd.)

- In a parallel circuit:

$$E_T = E_{R_1} = E_{R_2} = E_{R_3} \ldots = E_{R_n}$$

$$I_T = I_{R_1} + I_{R_2} + I_{R_3} \ldots + I_{R_n}$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots + \frac{1}{R_n}$$

Application of Ohm's Law (cont'd.)

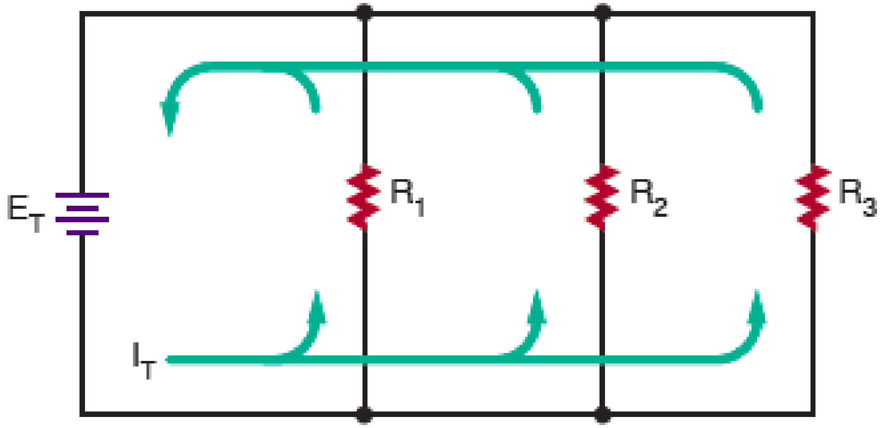


Figure 5-13. In a parallel circuit, the current divides among the branches of the circuit and recombines on returning to the voltage source.

Application of Ohm's Law (cont'd.)

- To determine unknown quantities:
  - Draw a schematic of the circuit and label all quantities
  - Solve for equivalent circuits and redraw the circuit
  - Solve for all unknown quantities
- Ohm's law applies to all series, parallel, and series-parallel circuits

Kirchhoff’s Current Law

- Kirchhoff’s current law (first law)
  - The algebraic sum of all the currents entering and leaving a junction is equal to zero
  - Restated: Total current into a junction is equal to the total current out of the junction
  - May be expressed as:

    $I_T = I_1 + I_2 + I_3$

Kirchhoff's Voltage Law

- Kirchhoff's voltage law (second law)
  - The algebraic sum of all the voltages around a closed circuit equals zero
  - Restated: The sum of all the voltage drops in a closed circuit will equal the voltage source
  - May be expressed as:

    $E_T – E_1 – E_2 – E_3 = 0$ or

    $E_T = E_1 + E_2 + E_3$

Summary

- An electric circuit consists of a voltage source, a load, and a conductor
- Current flow can be varied by changing the voltage or resistance
- Ohm's law defines the relationship among current, voltage, and resistance: $I = E/R$
- Kirchhoff's current law and voltage law define algebraic sums

Chapter 6

Electrical Measurements – Meters

Objectives

- After completing this chapter, you will be able to:
  - Identify the two types of meter movements available
  - Describe how a voltmeter is used in a circuit
  - Describe how an ammeter is used in a circuit
  - Describe how an ohmmeter is used for measuring resistance

Objectives (cont'd.)

- Identify the functions of a multimeter
- Identify the advantages/disadvantages of DMMs and VOMs
- Describe how to use a multimeter to measure voltage, current, and resistance
- Describe how to measure current using an ammeter
- Describe how to connect an ammeter into a circuit

Objectives (cont'd.)

- List safety precautions for using an ammeter
- Describe how to connect a voltmeter to an electrical circuit
- List safety precautions for connecting a voltmeter to a circuit
- Describe how resistance values are measured using an ohmmeter
- Define *continuity check*

Objectives (cont'd.)

– Describe how an ohmmeter is used to check open, short, or closed circuits

Introduction to Meters

- Analog meter
  - Uses a graduated scale with a pointer
- Digital meter
  - Provides a reading in numbers
  - More accurate than analog meters

Types of Meters

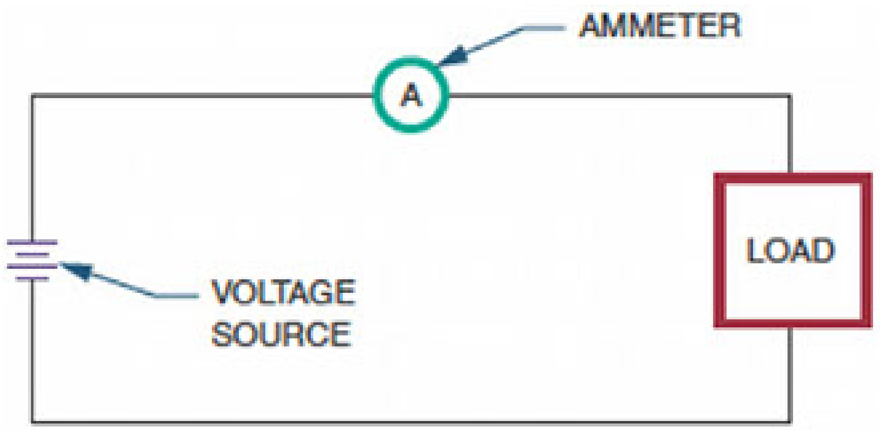


Figure 6-5. The placement of an ammeter in a circuit.

Types of Meters (cont'd.)

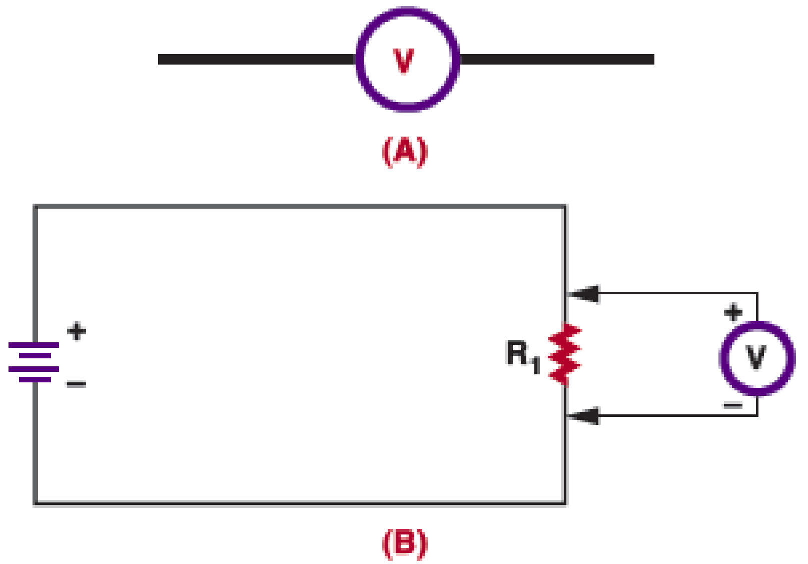


Figure 6-6. (A) Schematic symbol for a voltmeter.
(B) A voltmeter is connected in parallel in a circuit.

Types of Meters (cont'd.)

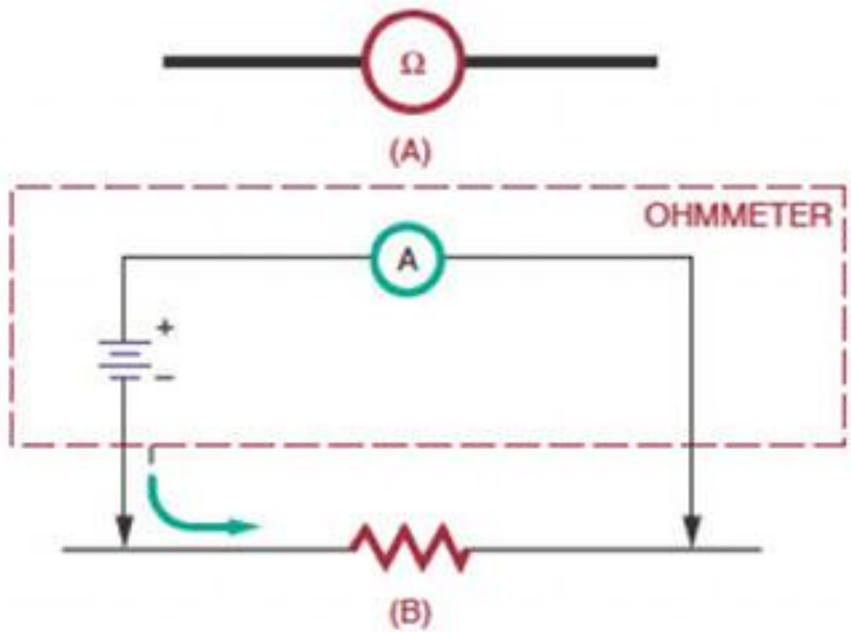


Figure 6-7. (A) Schematic symbol for an ohmmeter. (B) An ohmmeter applies a voltage across the component being measured and monitors the current flowing through it.

Multimeters

- Multimeter
  - Combines a voltmeter, ammeter, and ohmmeter into one package
- VOM (volt-ohm-milliammeter)
  - An analog multimeter that measures volts, ohms, and milliamperes
- DMM
  - A digital multimeter

Figure 6-8. An analog multimeter.

Multimeters (cont'd.)

- Advantages of DMMs over VOMs:
  - Easier readability, resulting in a higher accuracy with smaller voltage
  - Autoranging capabilities
  - Autozeroing for resistance reading
  - Autolock of a displayed value

Multimeters (cont'd.)

- Disadvantages of a DMM:
  - Requirement for source of electricity
  - Voltage limitation
  - Inability to measure an instantaneous change in a signal faster than the sampling time

Measuring Current

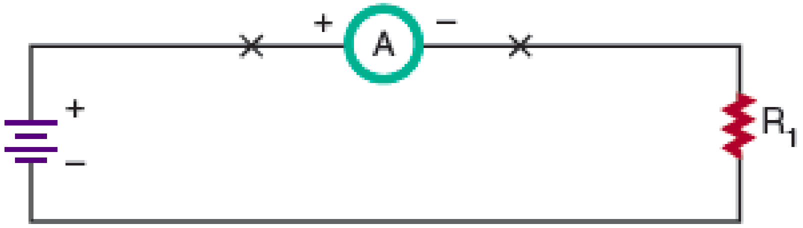


Figure 6-9. An ammeter is connected in series to a circuit.

Figure 6-10. An ammeter is one part of this VOM. A black negative lead plugs into the common or negative hack. A red positive lead plugs into the jack with the plus symbol.

Measuring Current (cont'd.)

- Caution:
  - Always turn off power before connecting an ammeter to a circuit
  - An analog ammeter must never be connected in parallel
  - Never connect an ammeter directly to a voltage source

Measuring Voltage

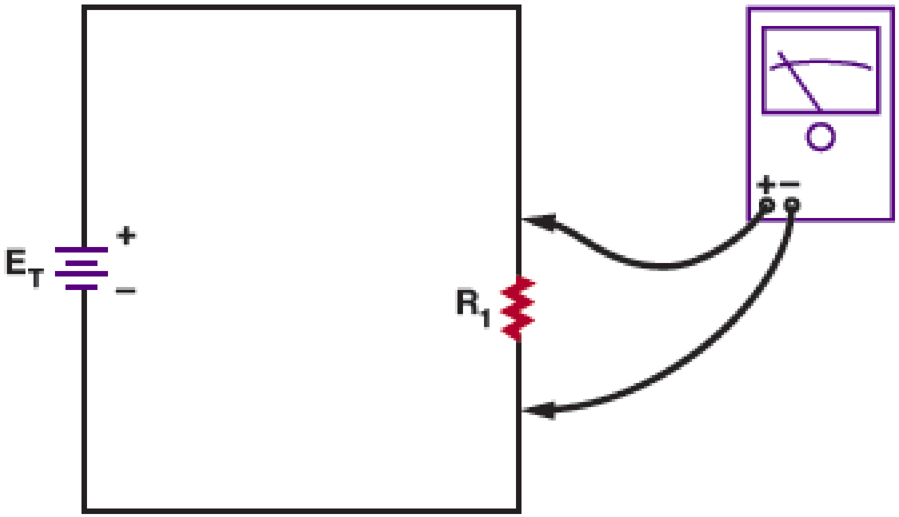


Figure 6-13. When connecting a voltmeter into a circuit, be sure to observe polarity.

Measuring Voltage (cont'd.)

- Caution:
  - If an analog voltmeter is connected in series with a circuit, a large current can flow through the meter and might damage it

Measuring Resistance

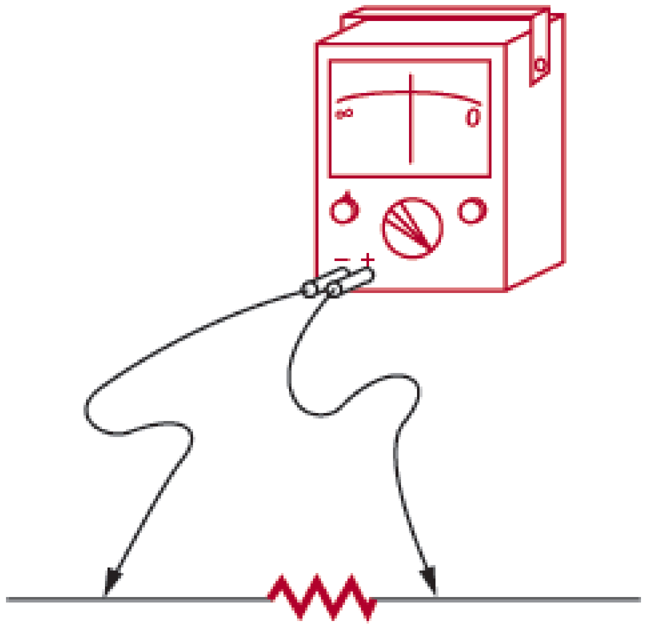


Figure 6-14. When using an ohmmeter to measure resistance, the component being measured must be removed from the circuit.

Measuring Resistance (cont'd.)

- Continuity test (or check)
  - Determines if current path is continuous
  - Open circuit
    - Indicates high resistance
  - Short circuit
    - Zero ohms of resistance
  - Closed circuit
    - Indicates low resistance

Reading Meter Scales

- Full scale value
  - Maximum value indicated by a meter
- Ammeters and voltmeters
  - Read from left to right
  - Linear scales
- Ohmmeters
  - Read from right to left
  - Nonlinear scales

Summary

- Analog meters use a graduated scale with a pointer
- Digital meters provide a direct readout
- A multimeter combines a voltmeter, ammeter, and ohmmeter into one package
- A VOM is an analog multimeter
- A DMM is a digital multimeter

Summary

- On a multimeter, the range selector switch selects the function to be used
- An ammeter must be connected in series with a circuit
- A voltmeter is connected in parallel with a circuit
- An ohmmeter measures resistance by applying a known voltage

Chapter 7: Power

Unit-I

ECE131-BEEE

Power

- **Power**
  - Rate at which energy is delivered to a circuit
  - Rate at which energy is dissipated by the resistance in a circuit
- **Watt**
  - Basic unit of power
- Relationship of power, current, and voltage may be expressed as:

P = I x E or V, where:

I represents current through the circuit

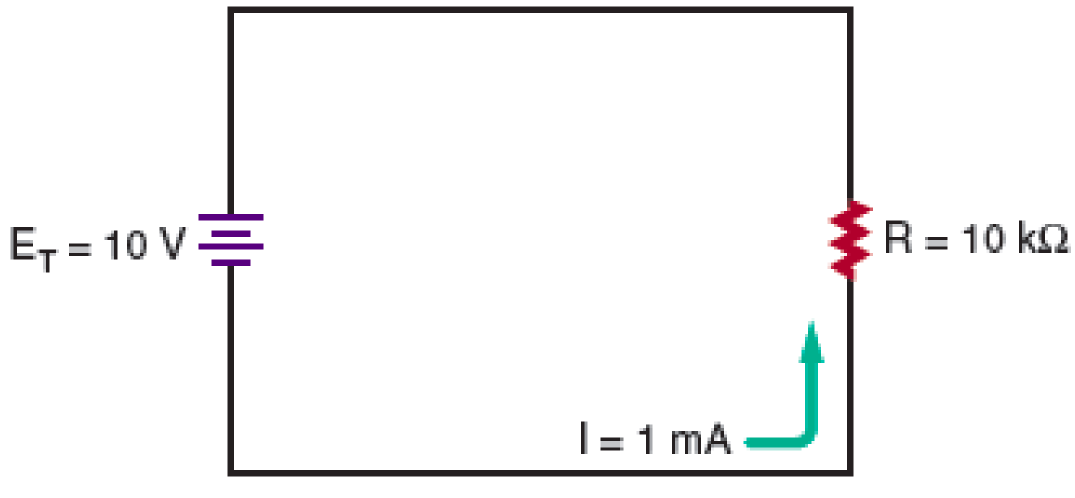
E (V) represents voltage applied to the circuit

Power Application (Circuit Analysis)

- Total power dissipated in a series or parallel circuit:

$$P_T = P_{R_1} + P_{R_2} + P_{R_3} \ldots + P_{R_n}$$

- Calculate the power consumed in the circuit?
- P = 10V x 1mA
- P =10mW



Power Application (Circuit Analysis)

- How much current does a 100Watts 120-Volt light bulb use?
- Given: Power: 100Watts and Voltage: 120V
- Solution: As $P = I \times V$
- $100 = I \times 120$
- Therefore $I = 100/120 = 0.83$Amps

Chapter 8 : DC Circuits

Unit-I

ECE131: BEEE

Objectives

- After completing this chapter, you will be able to:
  - Solve for all unknown values (current, voltage, resistance, and power) in a series, parallel, or series-parallel circuit
  - Understand the importance of voltage dividers
  - Design and solve for all unknown values in a voltage-divider circuit

Series Circuits

- In a series circuit:

$$I_T = I_{R_1} = I_{R_2} = I_{R_3} \ldots = I_{R_n}$$

$$R_T = R_1 + R_2 + R_3 \ldots + R_n$$

$$E_T = E_{R_1} + E_{R_2} + E_{R_3} \ldots + E_{R_n}$$

Series Circuits (cont'd.)

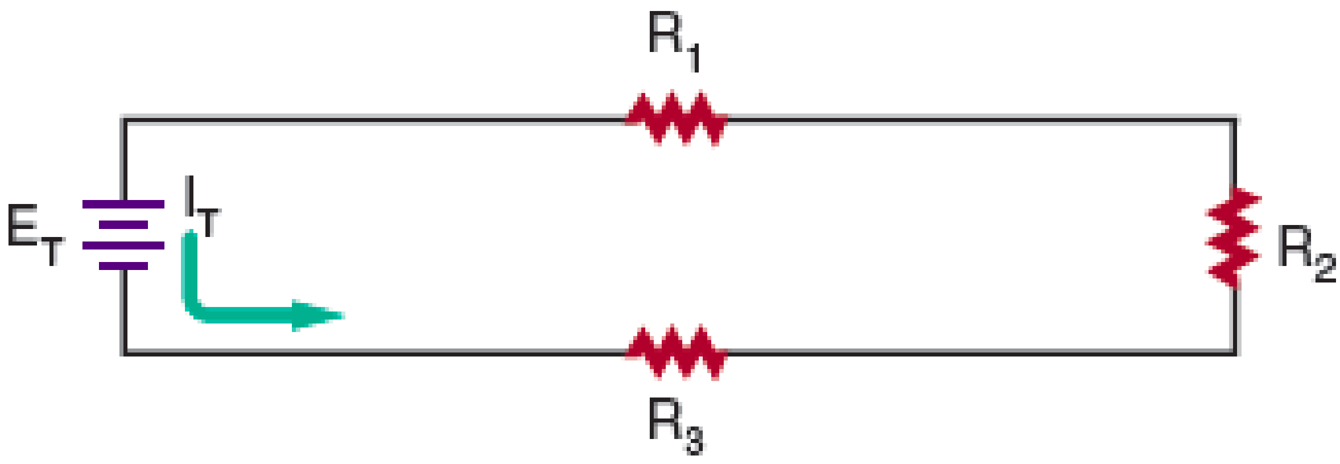


Figure 8-1. Series circuit.

$$I = E/R$$

$$P_T = P_{R_1} + P_{R_2} + P_{R_3} \cdots + P_{R_N}$$

Parallel Circuits

- In a parallel circuit:

$$E_T = E_{R_1} = E_{R_2} = E_{R_3} \ldots = E_{R_n}$$

$$I = E/R$$

$$I_T = I_{R_1} + I_{R_2} + I_{R_3} \ldots + I_{R_n}$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots + \frac{1}{R_n}$$

$$P_T = P_{R_1} + P_{R_2} + P_{R_3} \ldots + P_{R_N}$$

Series-Parallel Circuits

- Series formulas are applied to the series part of the circuit
- Parallel formulas are applied to the parallel part

Voltage Dividers

- Sets the *bias* or operating point of active electronic components
- Also used in *scaling*

Voltage Dividers (cont'd.)

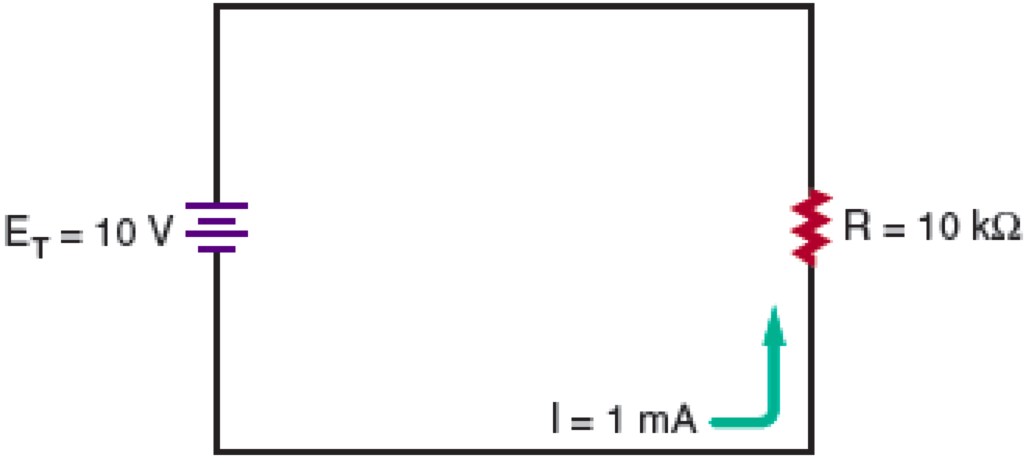


Figure 8-11. Simple circuit.

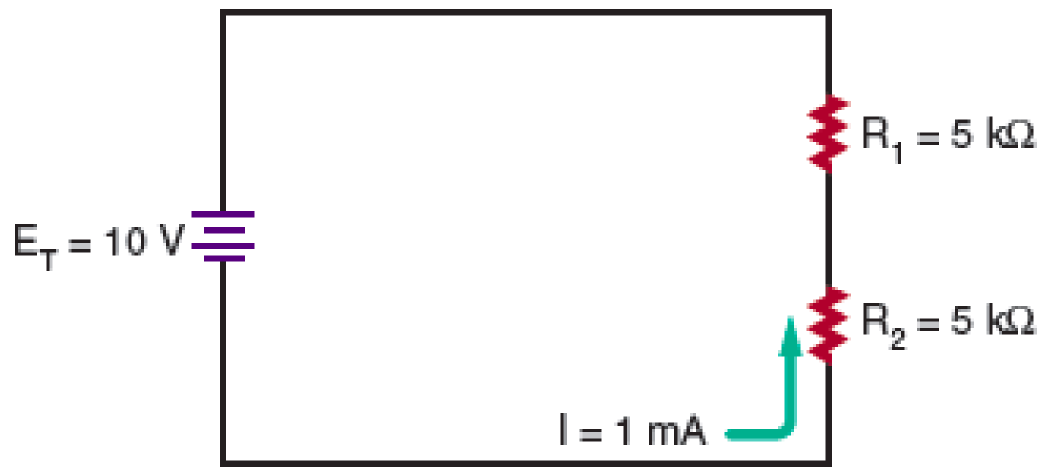


Figure 8-12. Simple voltage divider.

Voltage Dividers (cont'd.)

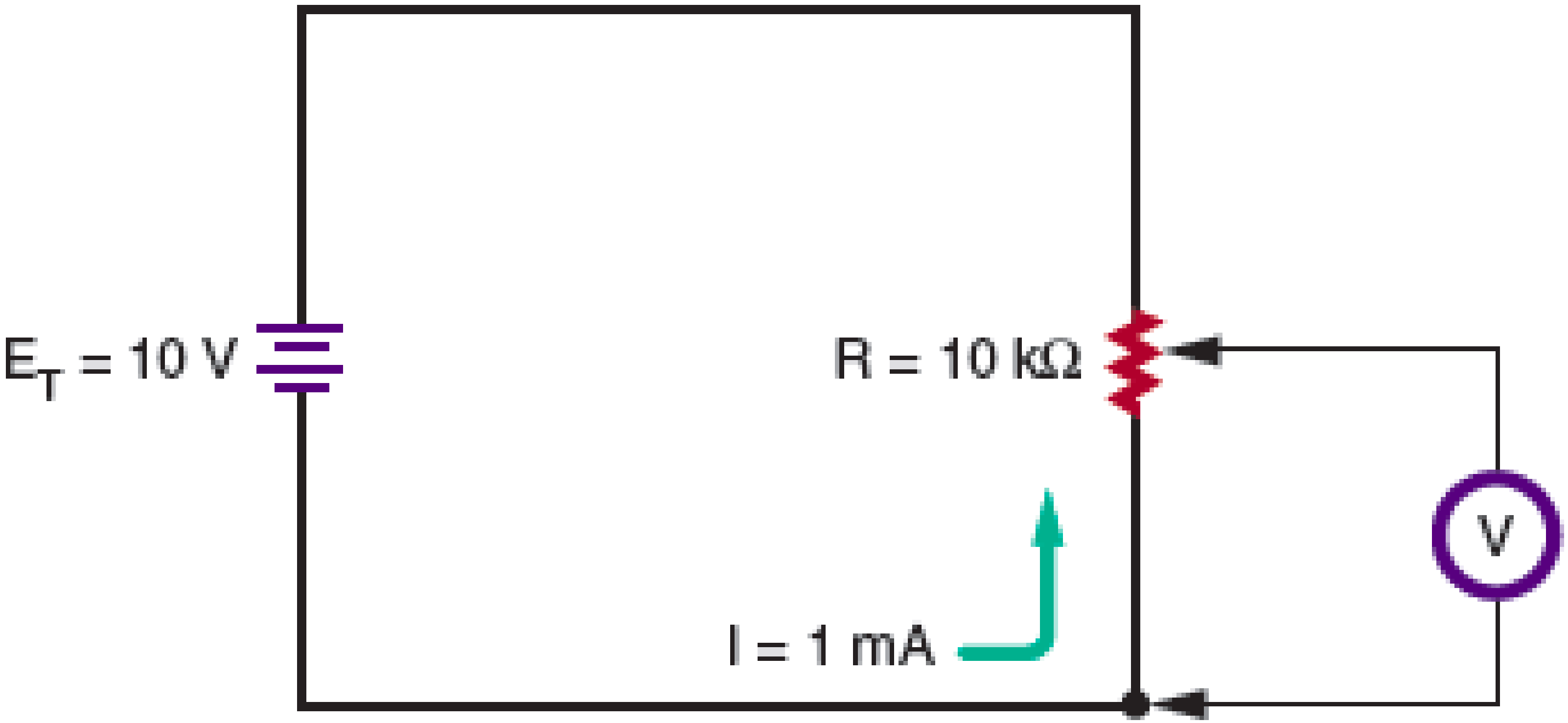


Figure 8-14. Voltage divider application.

Voltage Dividers (cont'd.)

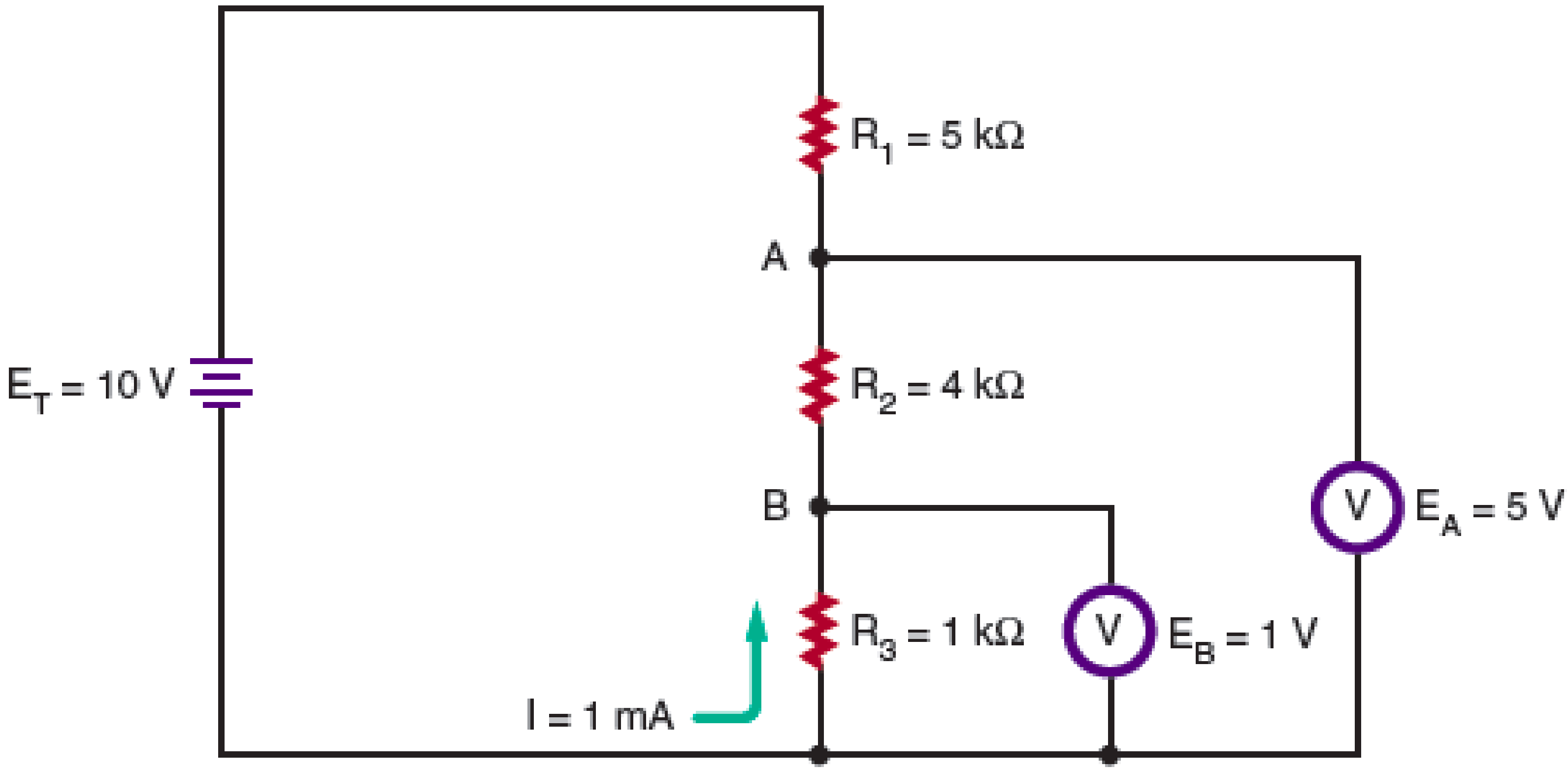


Figure 8-13. Voltage divider.

Voltage Dividers (cont'd.)

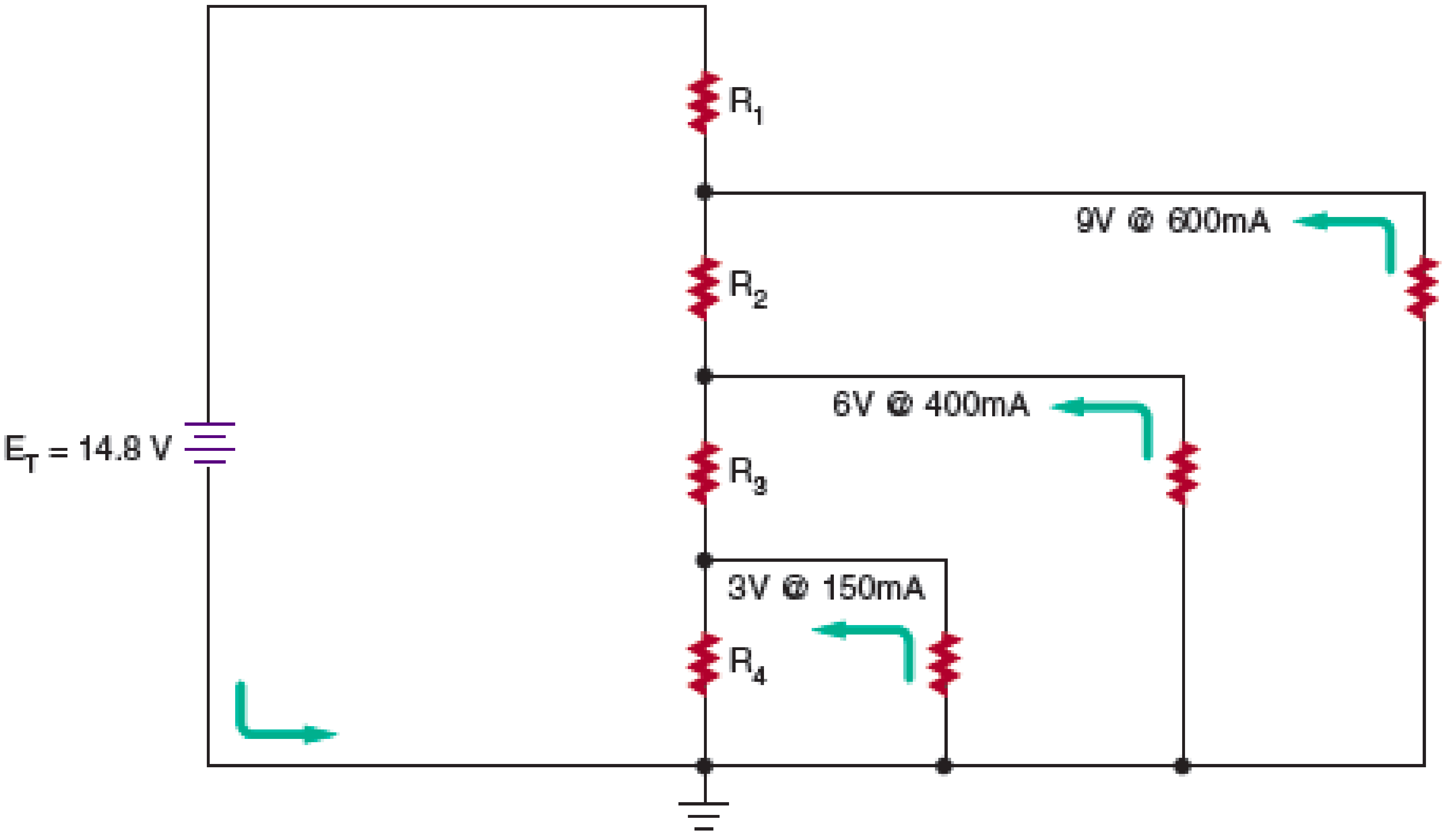


Figure 8-16. Real-world voltage divider.

Real-world voltage divider

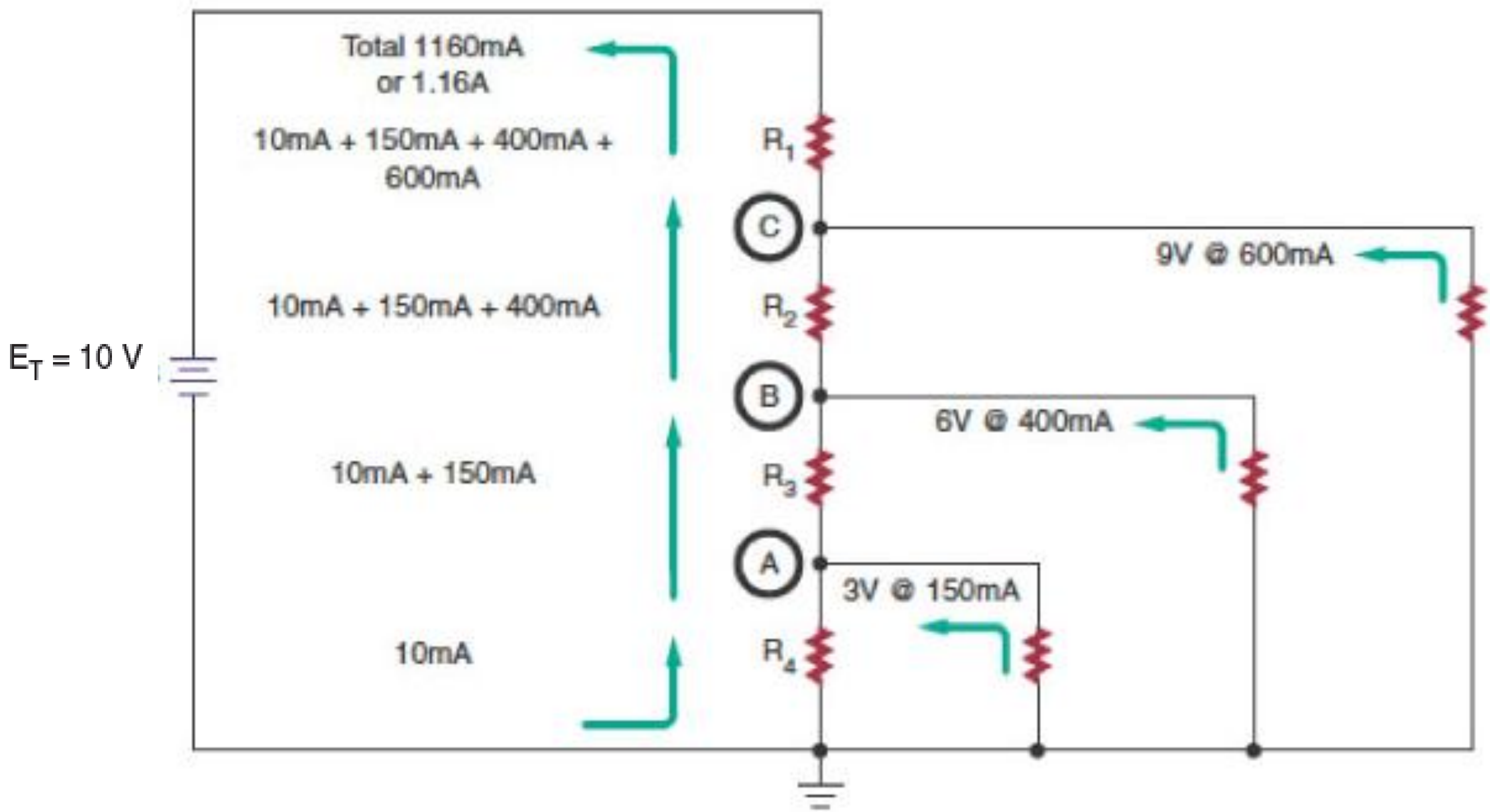


Figure 8-17. Analyzing the circuit.

Voltage Dividers (cont'd.)

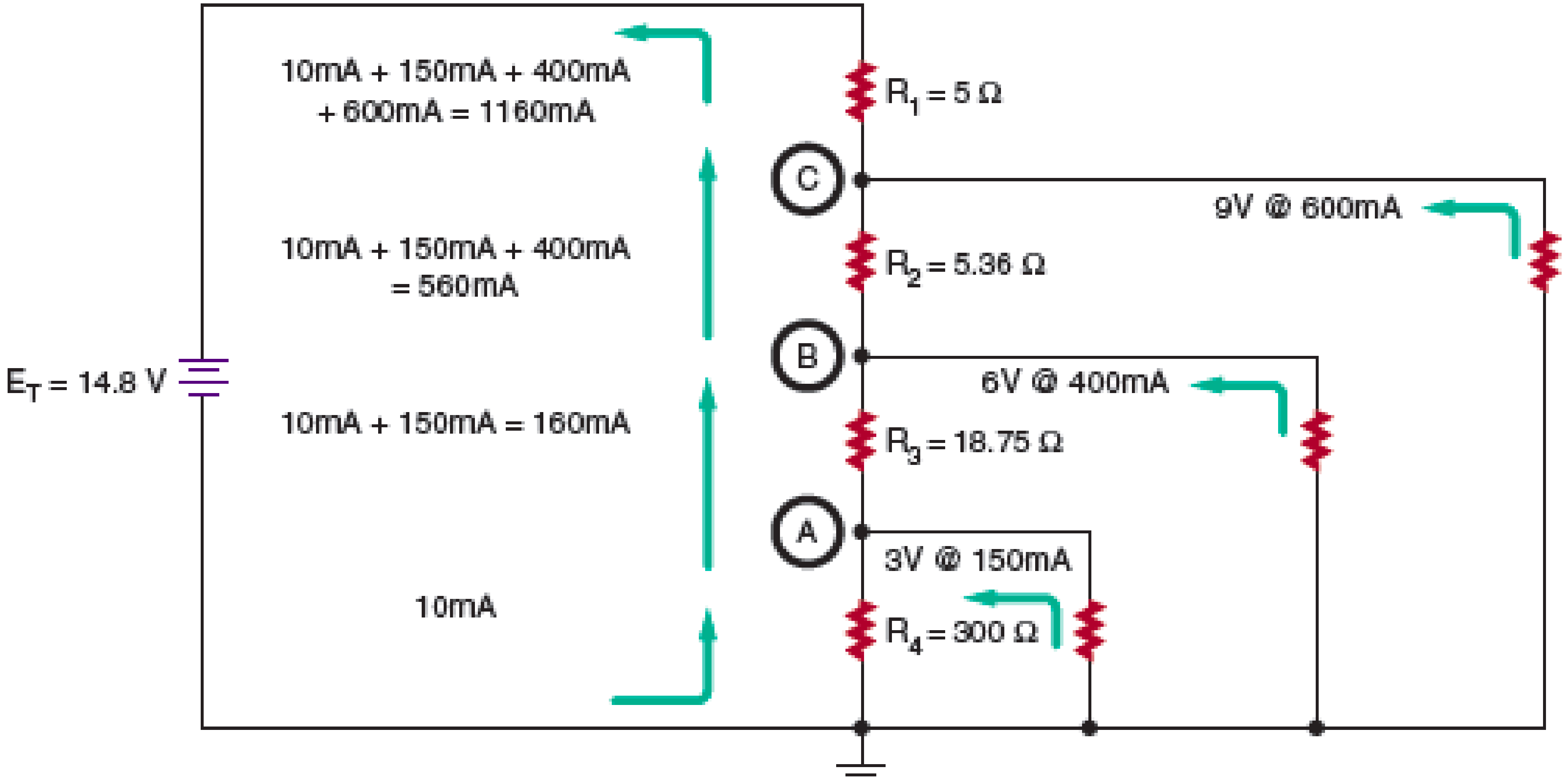


Figure 8-18. Determining the resistor values.

Wheatstone Bridge

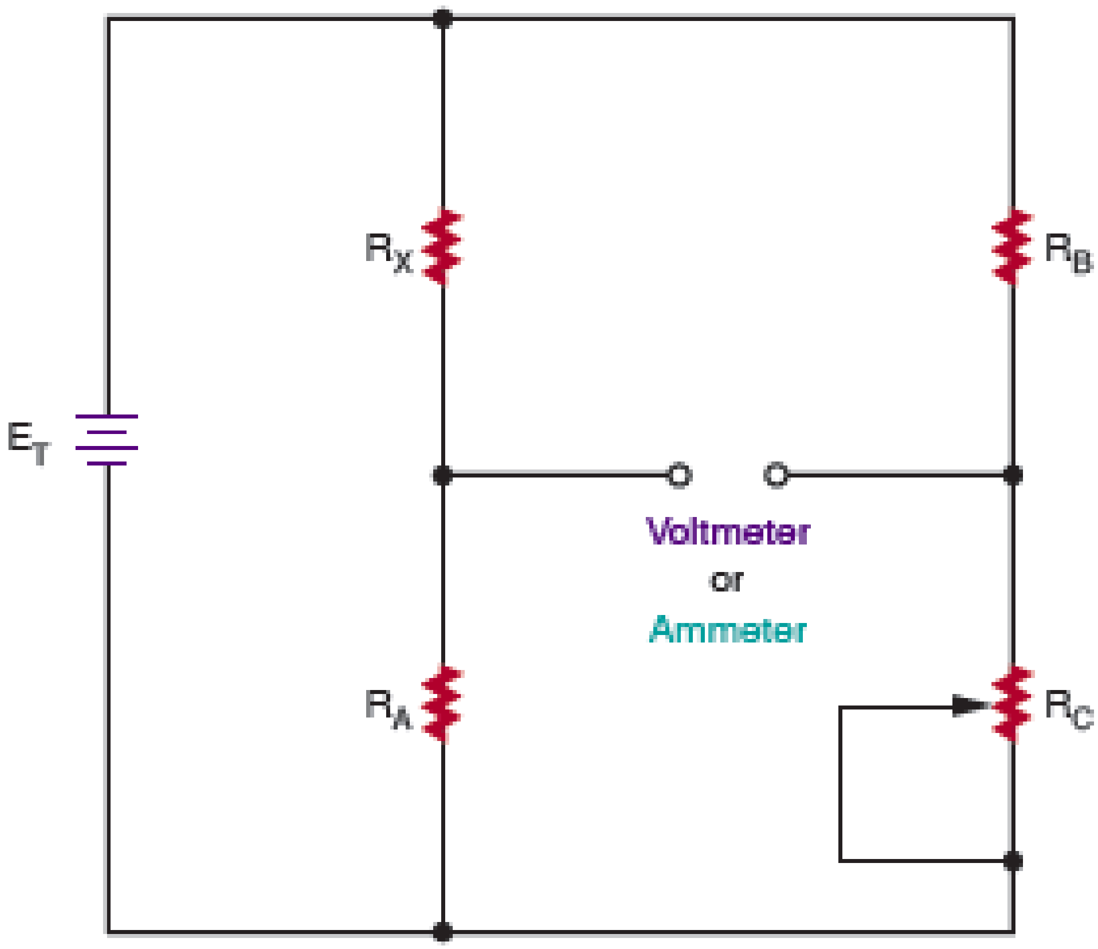


Figure 8-19. A Wheatstone bridge consists of two voltage dividers.

Summary

- The most commonly used circuits are the series, parallel, and series-parallel circuits
- Voltage dividers sets the bias of active electronic components
- A Wheatstone bridge measures unknown electrical resistance

Chapter 9

Magnetism

Objectives

- After completing this chapter, you will be able to:
  - Identify three types of magnets
  - Describe the basic shapes of magnets
  - Describe the differences between permanent magnets and temporary magnets
  - Describe how the earth functions as a magnet
  - State the laws of magnetism
  - Identify flux lines and their significance

Objectives (cont'd.)

– Describe the principle of an electromagnet
– Describe how magnetism is used to generate electricity
– State the basic law of electromagnetism
– Describe how the left-hand rule for generators can be used to determine the polarity of induced voltage
– Describe how AC and DC generators convert mechanical energy into electrical energy

Magnetic Fields

- Magnetite
  - Natural magnet
- Artificial magnet
  - Created by rubbing soft iron with another magnet
- Electromagnet
  - Created by current flowing through a coil of wire

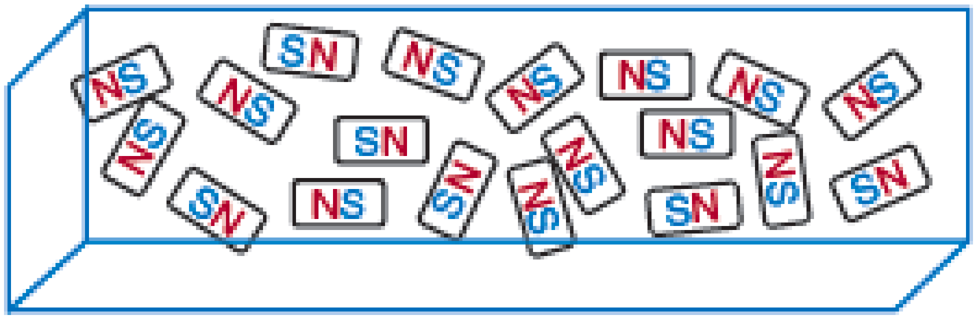


Figure 9-3. The domains in **un-magnetized** material are randomly arranged with no overall magnetic effect

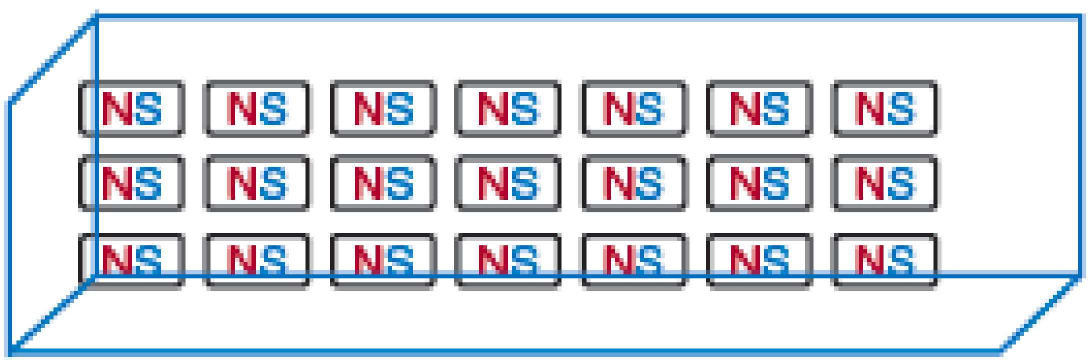


Figure 9-4. When material becomes magnetized, all the **domains align** in a common direction.

Magnetic Fields (cont'd.)

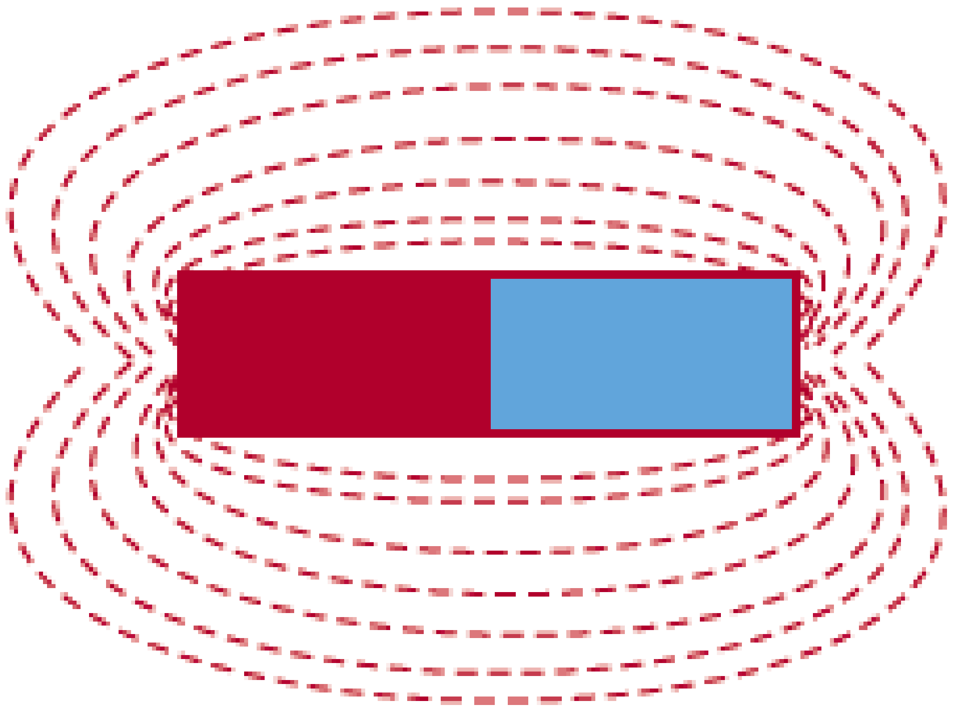


Figure 9-6. Magnetic lines of flux can be seen in patterns of iron filings.

Electricity and Magnetism

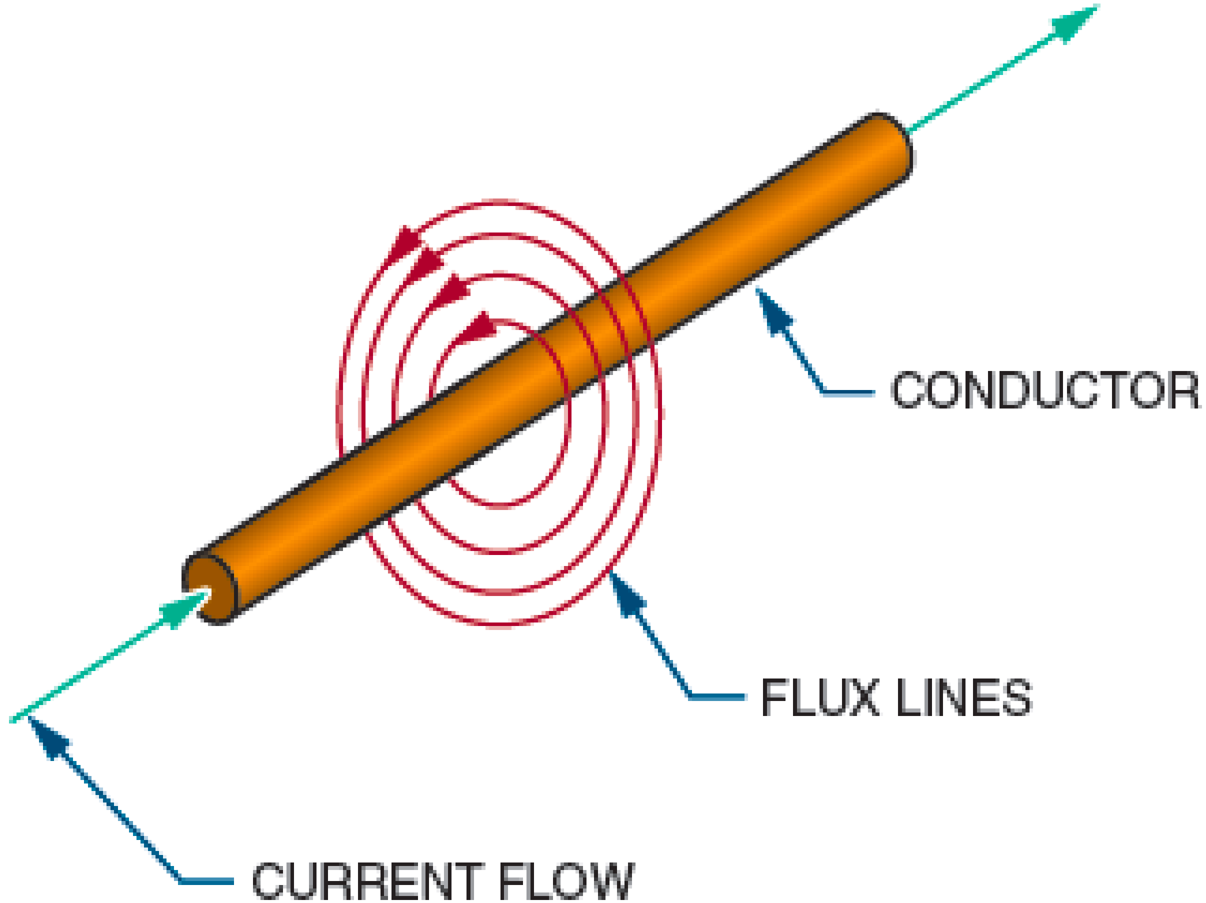


Figure 9-7. A current flowing through a conductor creates a magnetic field around the conductor.

Left Hand Rule

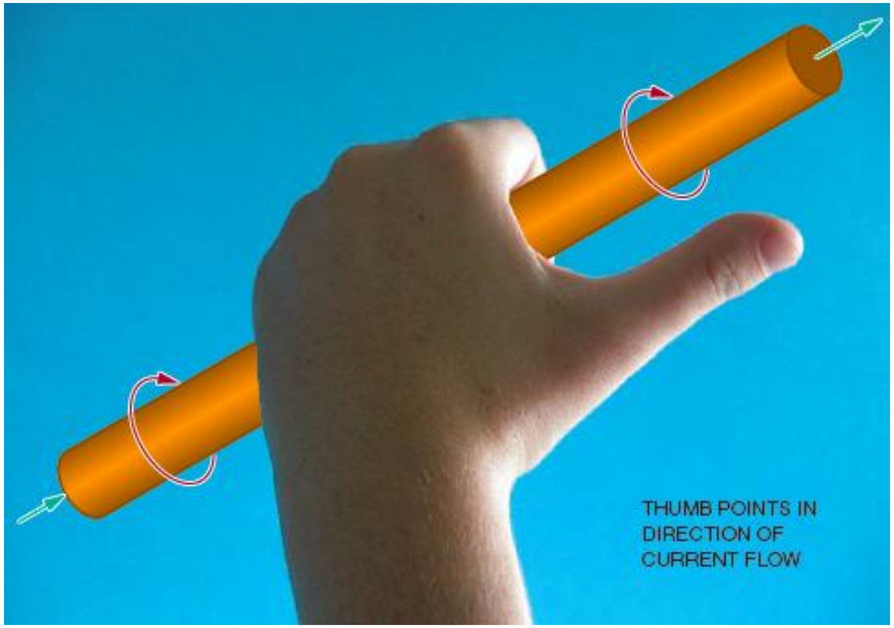


Figure 9-8. Determining the direction of the flux lines around a conductor when the direction of the current flow is known

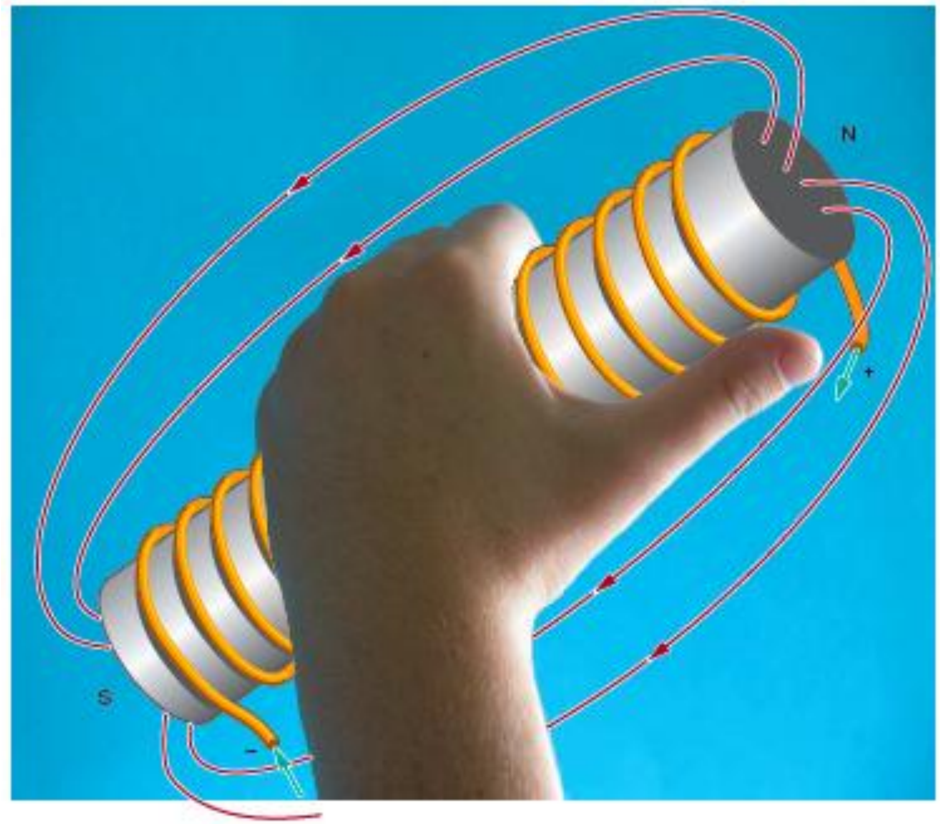


Figure 9-11. Determining the polarity of an electromagnet (left-hand rule for coils).

Electricity and Magnetism (cont'd.)

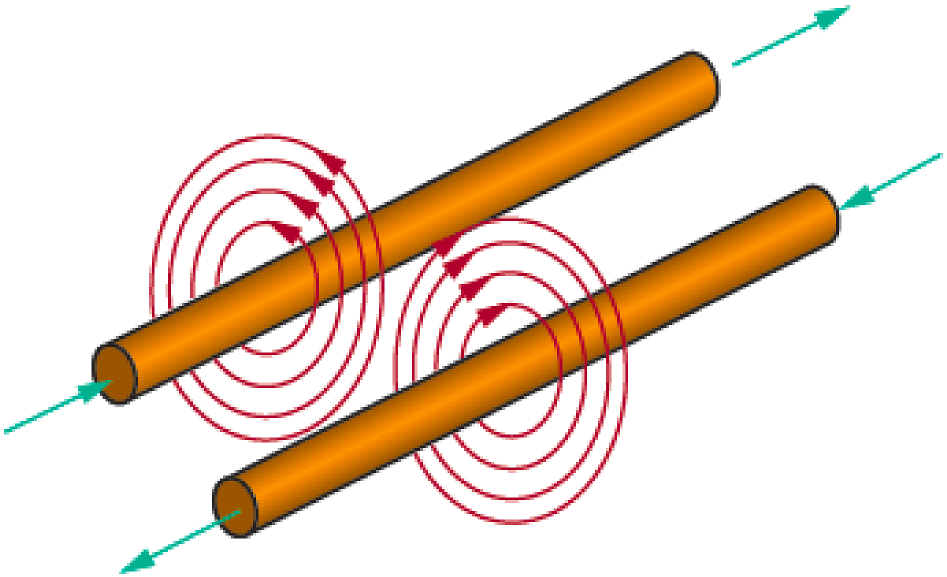


Figure 9-9. When current flows in **opposite directions** through two conductors placed next to each other, the resulting magnetic fields repel each other.

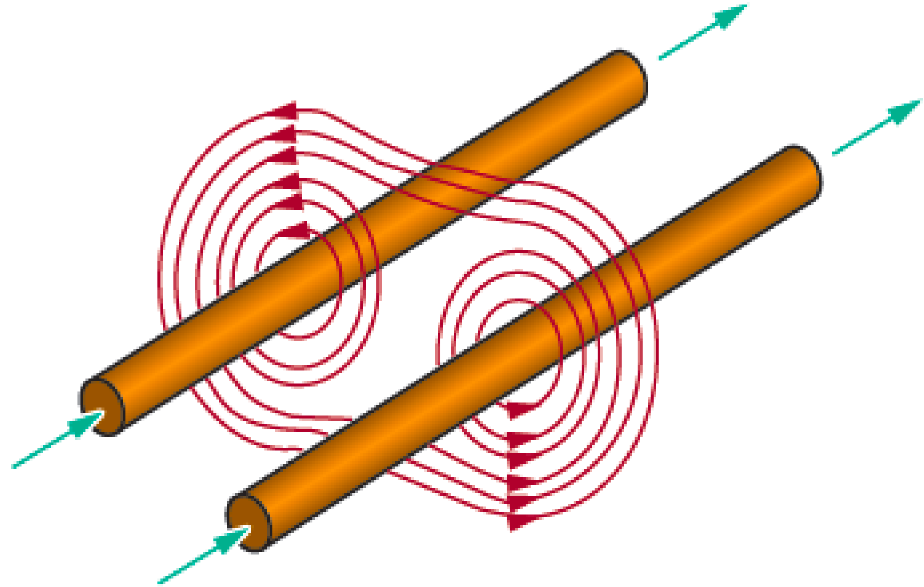


Figure 9-10. When current flows in the **same direction** through two conductors placed next to each other, the magnetic fields combine.

Magnetic Induction

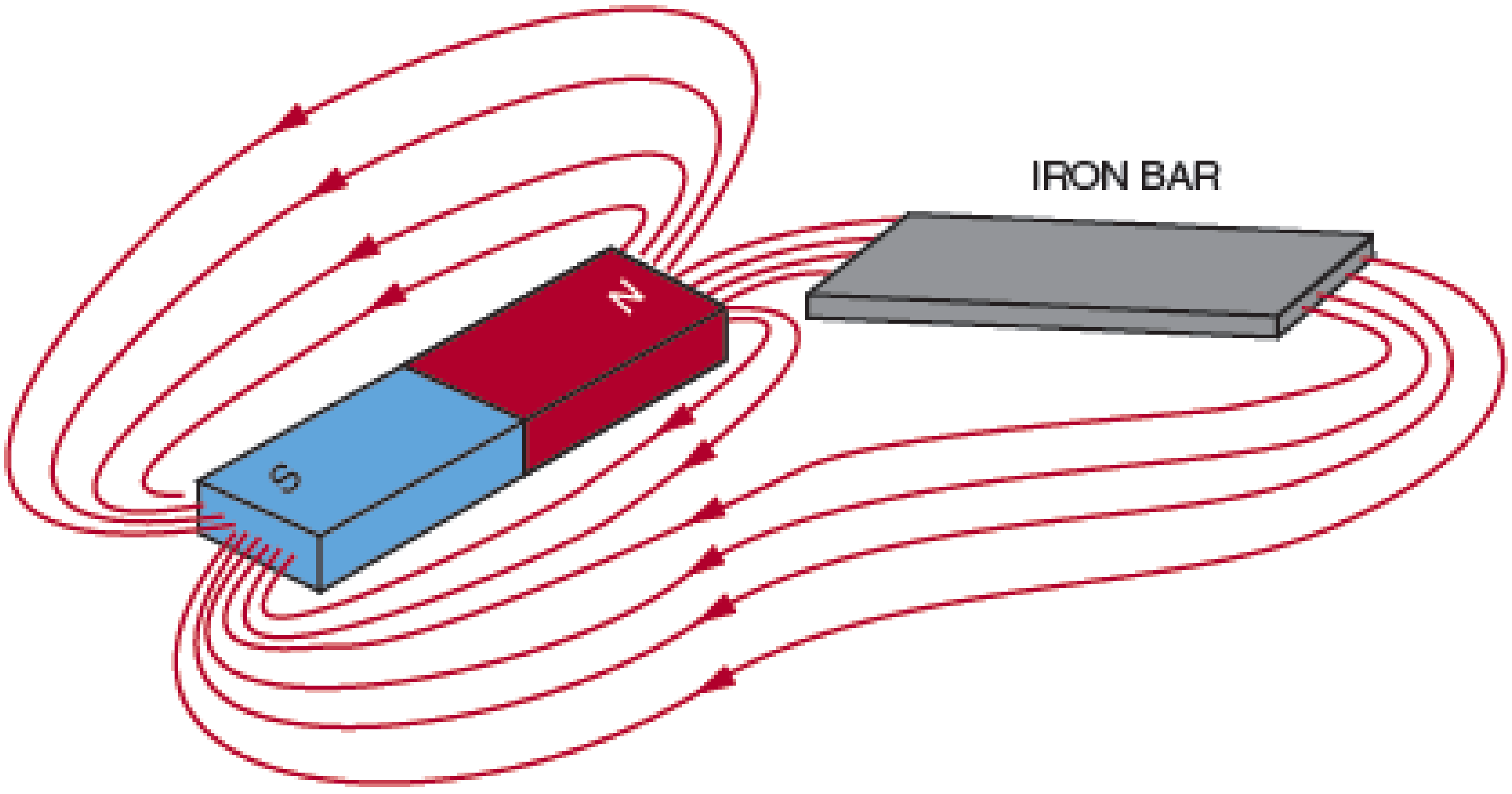


Figure 9-12. Placing an iron bar in a magnetic field extends the magnetic field and magnetizes the iron bar.

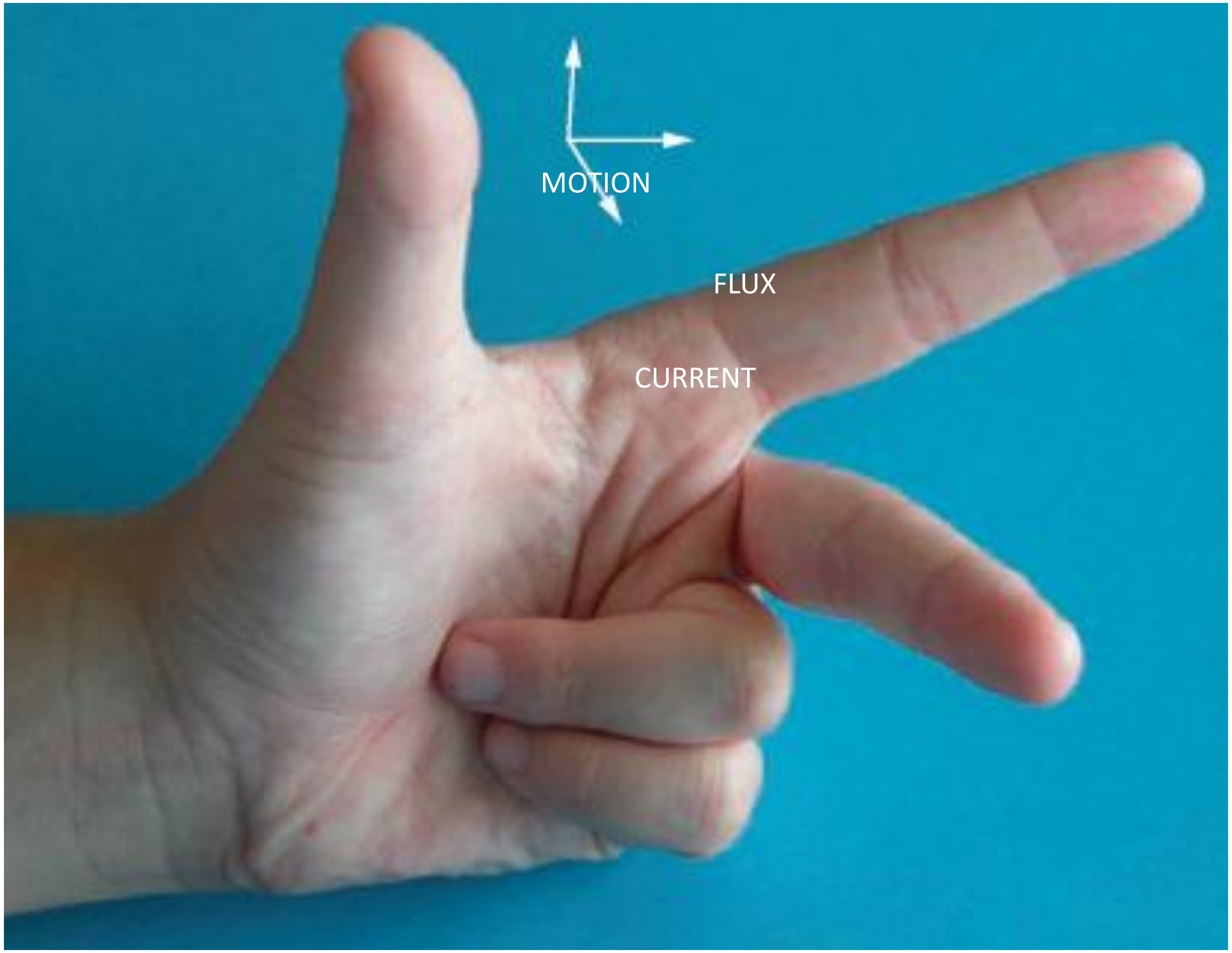
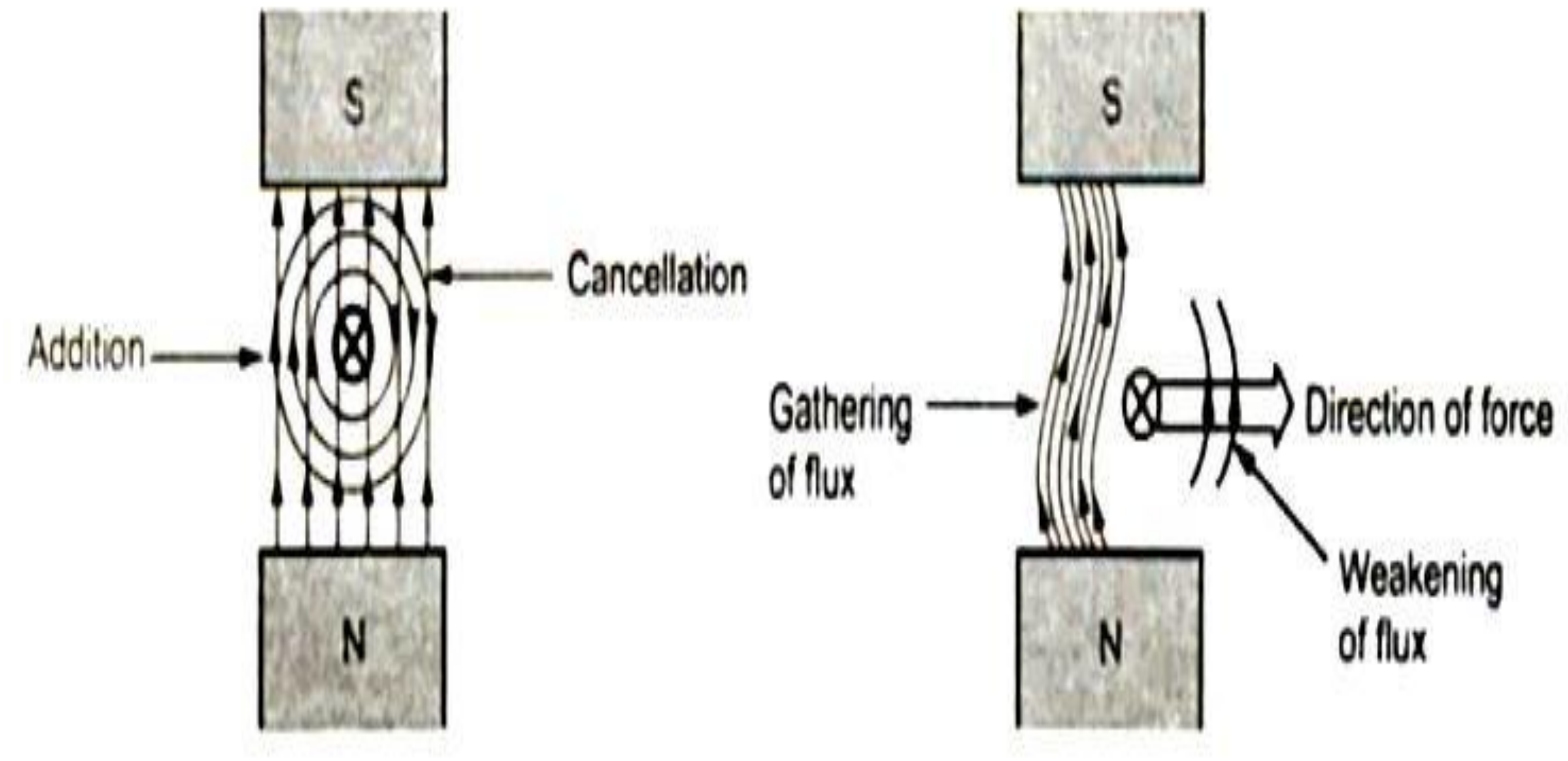
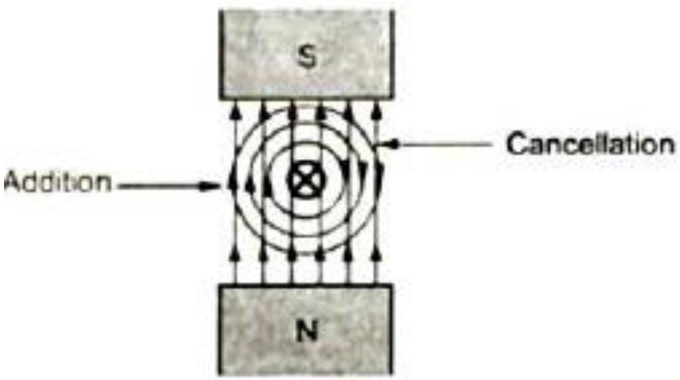


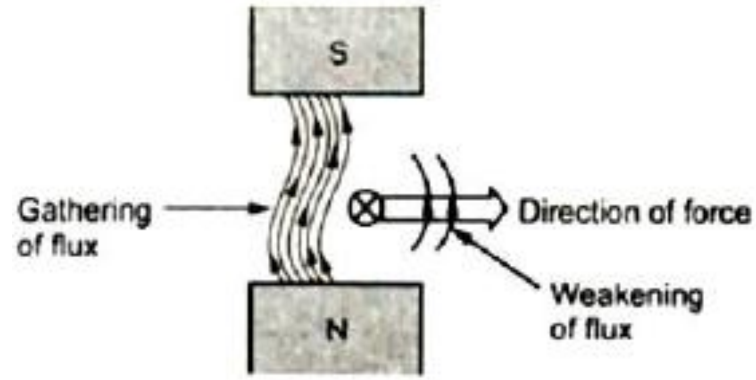
Figure 9-13. The left-hand rule for generators can be used to determine the direction of the induced current flow in a generator.

Interaction of fluxes and Force experienced by conductor



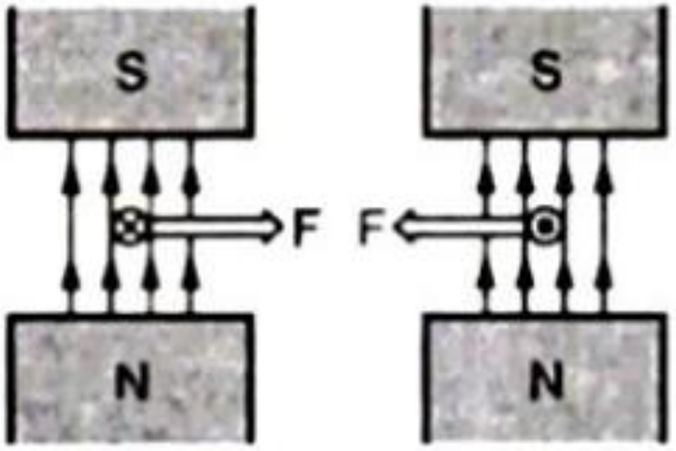
Interaction of fluxes





- The flux lines produced by the magnet and the conductor are in the opposite directions to each other at the right and hence cancel each other.
- Hence the number of flux lines at the right will reduce as shown in Figure right hand side.
- At the left, the individual fields are in the same direction, hence will add or strengthen each other.
- Therefore the number of flux lines at the left side will increase as shown in Figure right hand side.

Magnitude of Force



- The magnitude of the force experienced by the current carrying conductor placed in the magnetic field is given by

  - F = B I L Newton

- Where,
- B = Flux density (Wb)
- I = Current flowing through the conductor (A)
- L = Length of the conductor (m)

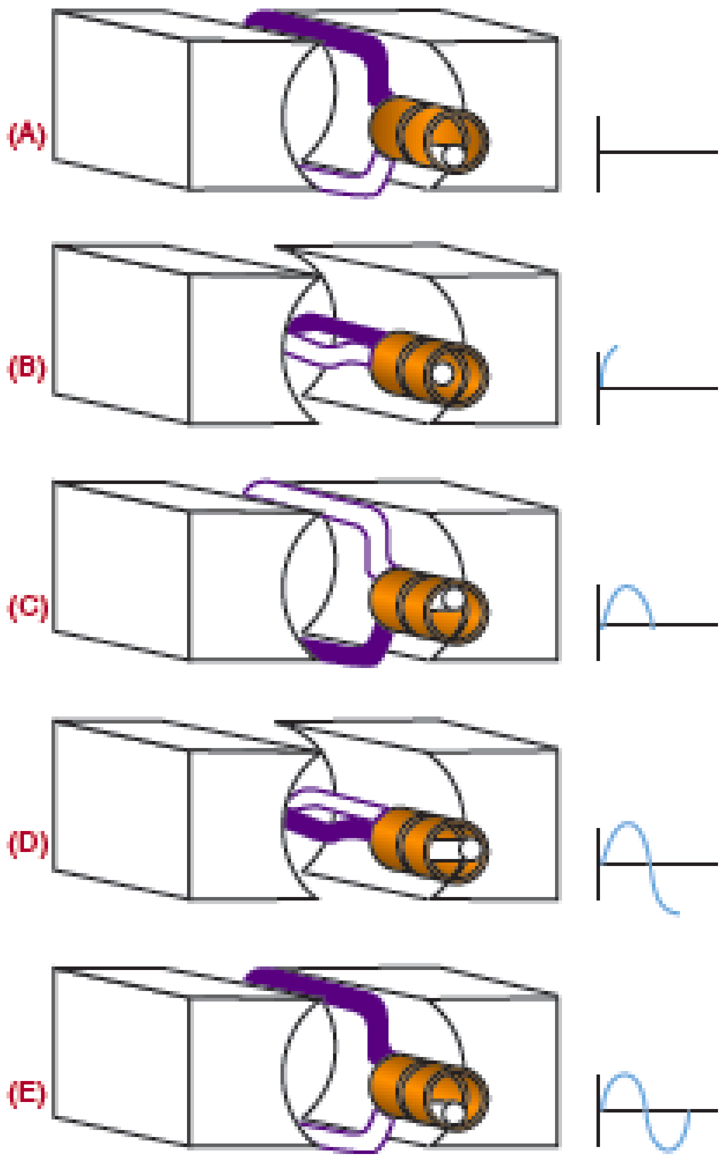


Figure 9-14. Induced voltage in an AC generator.

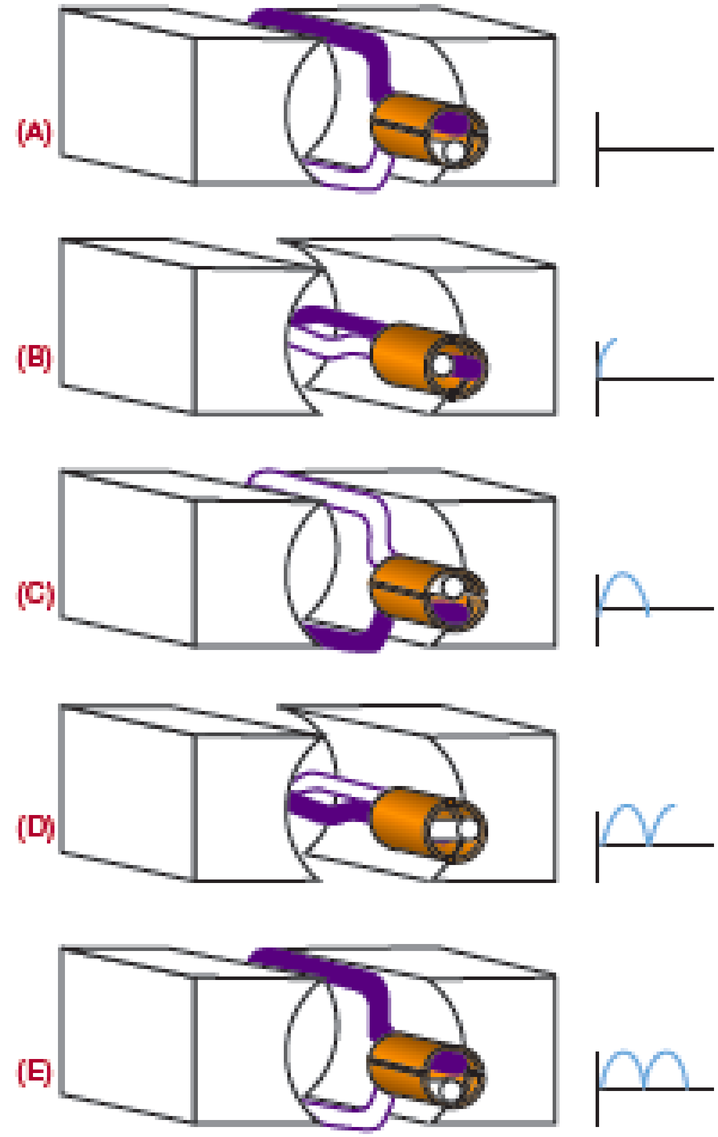
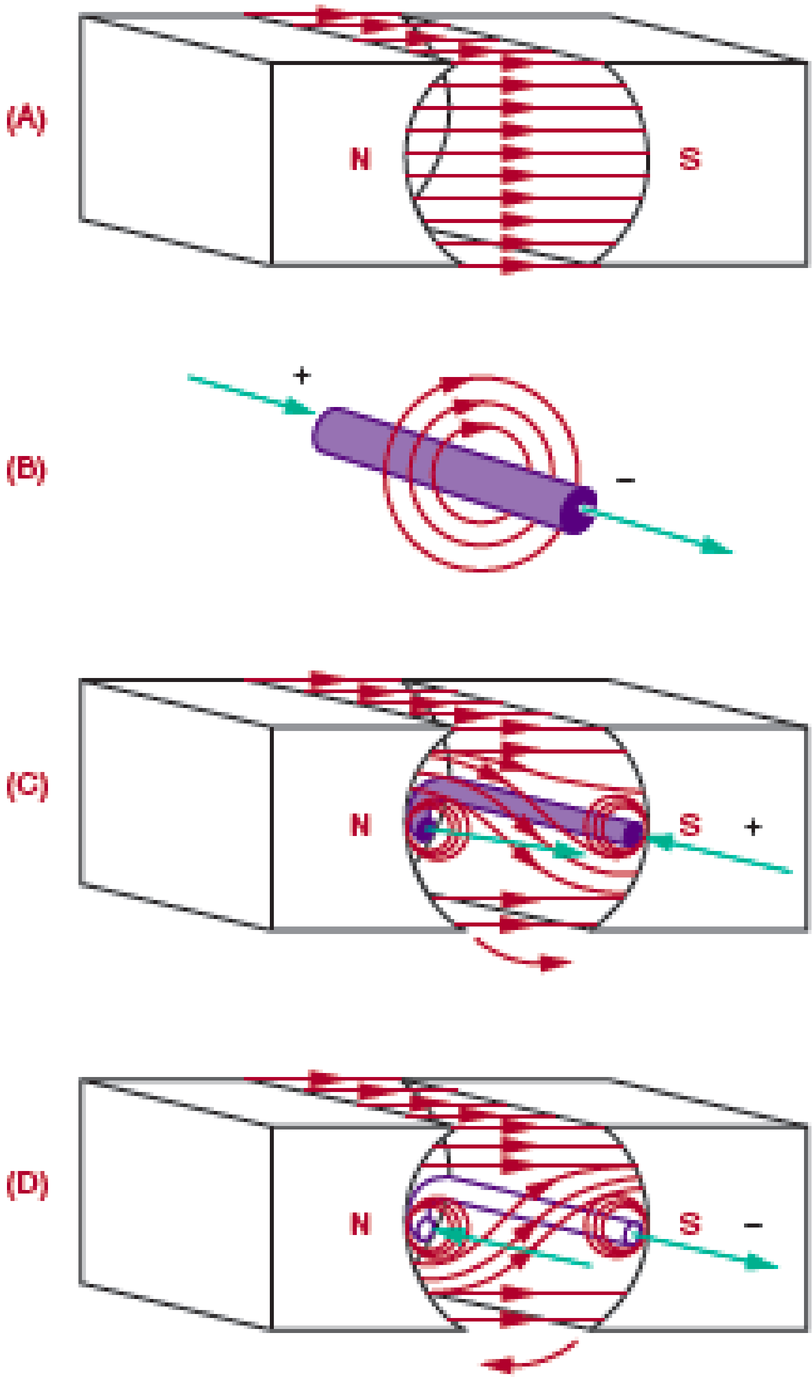


Figure 9-15. Induced voltage in an DC generator.



https://www.youtube.com/watch?v=fWyzPdyCAzU

https://www.youtube.com/watch?x-yt-ts=1422327029&v=LAtPHANEfQo&x-yt-cl=84838260

Figure 9-18. Operation of a DC motor.

Summary

- Electric current always produces some form of magnetism
- Magnetism is the most common method for generating electricity
- One theory of magnetism is based on the spin of electrons as they orbit around an atom
- Another theory of magnetism is based on the alignment of domains
- A magnetic field surrounds a wire when current flows through it
- Left-hand rule: for conductors, coils, and generators
- Faraday's law: the basic law of electromagnetism

Chapter 10

Inductance

Objectives

- After completing this chapter, you will be able to:
  - Explain the principles of inductance
  - Identify the basic units of inductance
  - Identify different types of inductors
  - Determine the total inductance in series and parallel circuits
  - Explain L/R time constants and how they relate to inductance

Inductance

- Inductance
  - Ability to store energy in a magnetic field
  - Represented by the letter *L*
- henry (H)
  - Unit for measuring inductance
- Inductors
  - Designed to have a specific inductance
  - Classified by the type of core material
    - Magnetic or nonmagnetic
  - Can be fixed or variable

Inductors (cont'd.)

Figure 10-4. An air-core inductor. **Fig 10-6. Toroid-core inductor.**

Inductors (cont'd.)

Figure 10-7.
Shielded inductor.

Figure 10-8. Laminated iron-core inductor.

Example: Tube light Choke

Inductors (cont'd.)

- Total inductance in series circuits:

$$L_T = L_1 + L_2 + L_3 \ldots + L_n$$

- Total inductance in parallel circuits:

$$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} \ldots + \frac{1}{L_n}$$

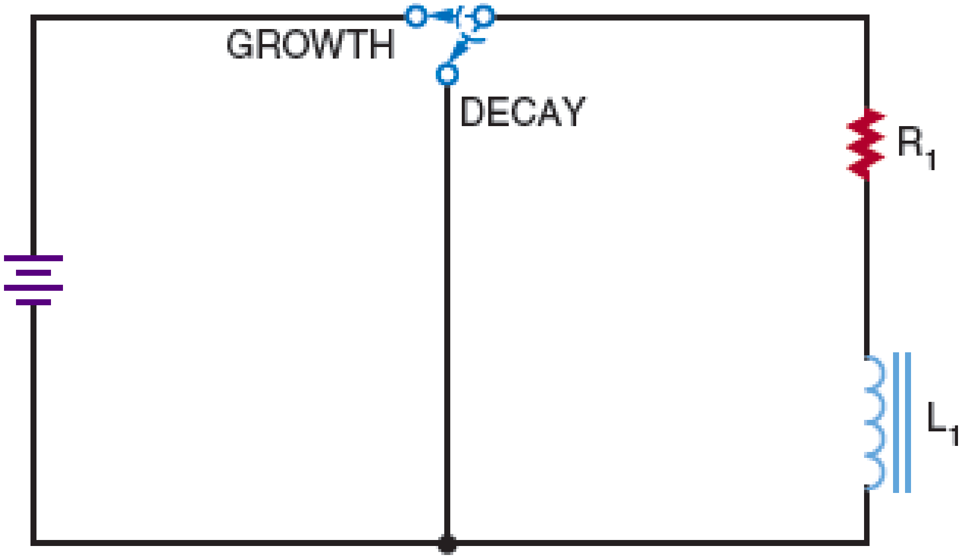
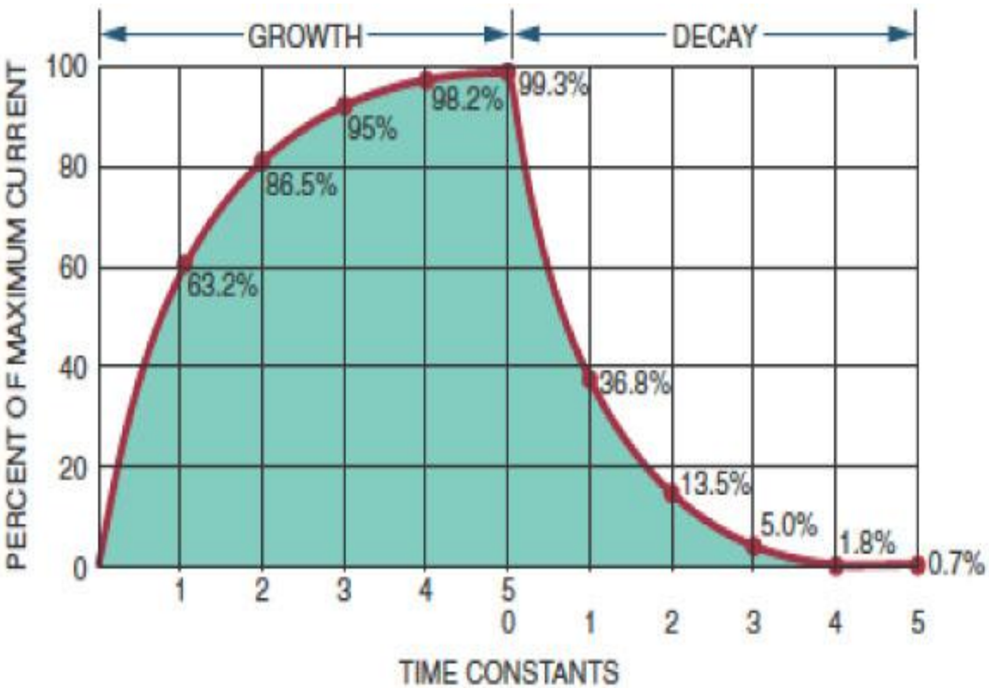


Figure 10-9. Circuit used to determine L/R time constant.



L/R Time Constants

- Time constant formula:

  t = L/R

  where:

  t = time in seconds

  L = inductance in Henries

  R = resistance in ohms

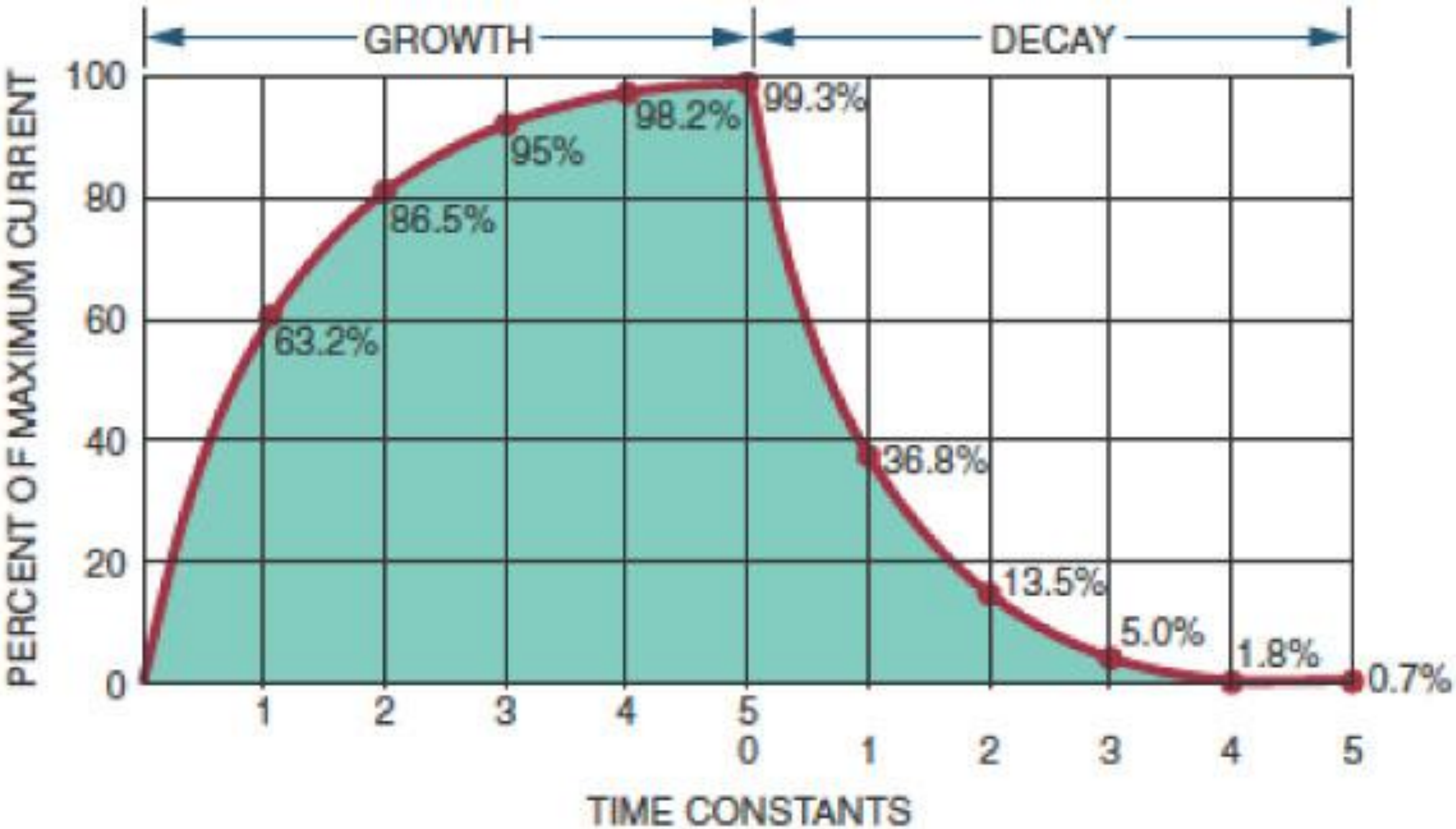


Figure 10-10. Time constants required to build up or collapse the magnetic field in an inductor.

Summary

- Inductance (*L*) is the ability to store energy in a magnetic field
- Unit for measuring inductance is the henry (H)
- Types of inductors include: air-core, ferrite or powdered iron core, toroid core, shielded, and laminated-iron core

Summary (cont'd.)

- Total inductance in series circuits:

$$L_T = L_1 + L_2 + L_3 \ldots + L_n$$

- Total inductance in parallel circuits:

$$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} \cdots + \frac{1}{L_n}$$

- Time constant formula:

$t = L/R$

Chapter 11

Capacitance

Objectives

- After completing this chapter, you will be able to:
  - Explain the principles of capacitance
  - Identify the basic units of capacitance
  - Identify different types of capacitors
  - Determine total capacitance in series and parallel circuits
  - Explain RC time constants and how they relate to capacitance

Capacitance

- Capacitance
  - Ability to store electrical energy in an electrostatic field
  - Basic unit is the farad (F)
  - Represented by letter *C*
- Capacitor
  - Possesses a specific amount of capacitance
  - Either fixed or variable

Capacitors

- Factors that affect capacitance
  - Area of the plate
  - Distance between the plates
  - Type of dielectric material
  - Temperature

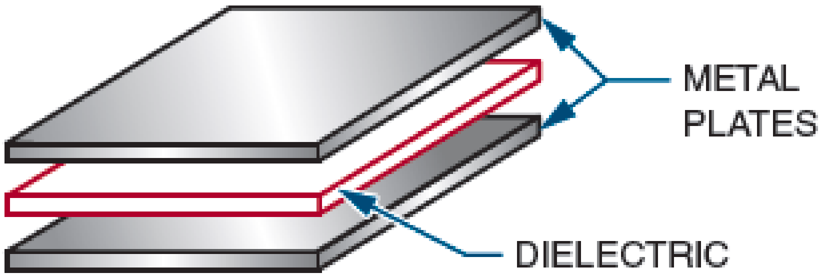
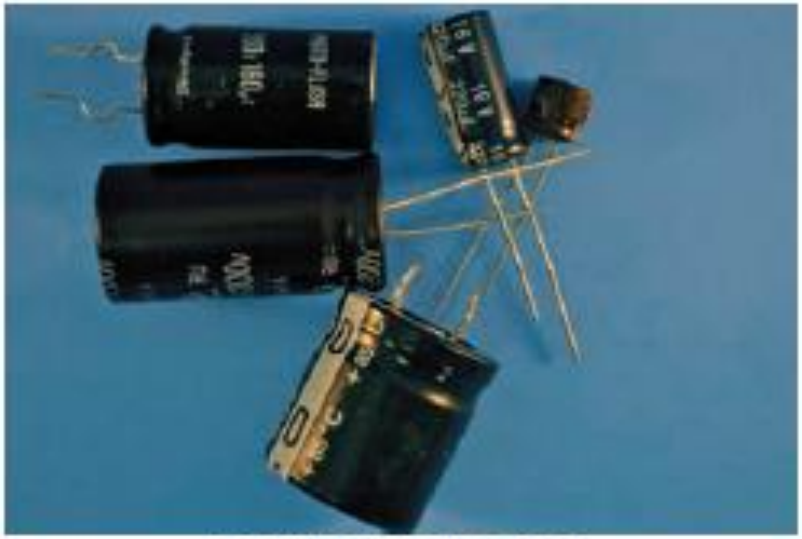
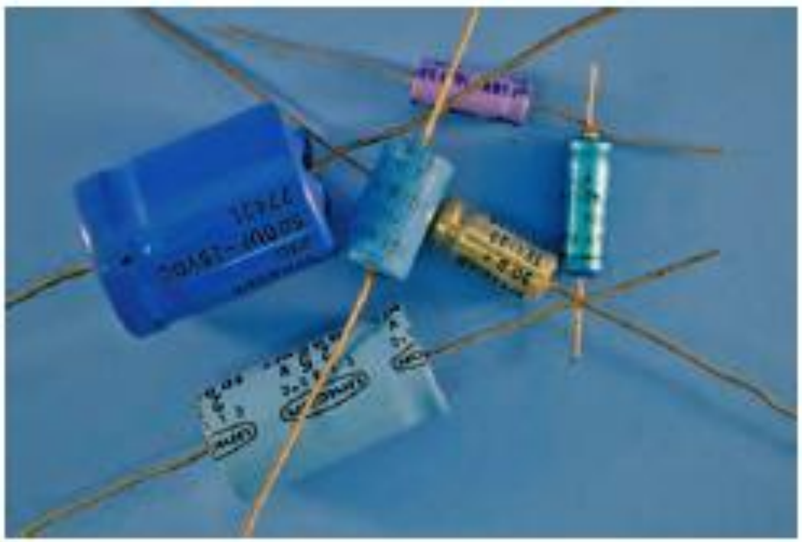


Figure 11-1. A capacitor consists of two plates (conductors) separated by a dielectric (insulator or nonconductor).

Capacitance (cont'd.)



RADIAL CAPACITOR LEAD



AXIAL CAPACITOR LEADS

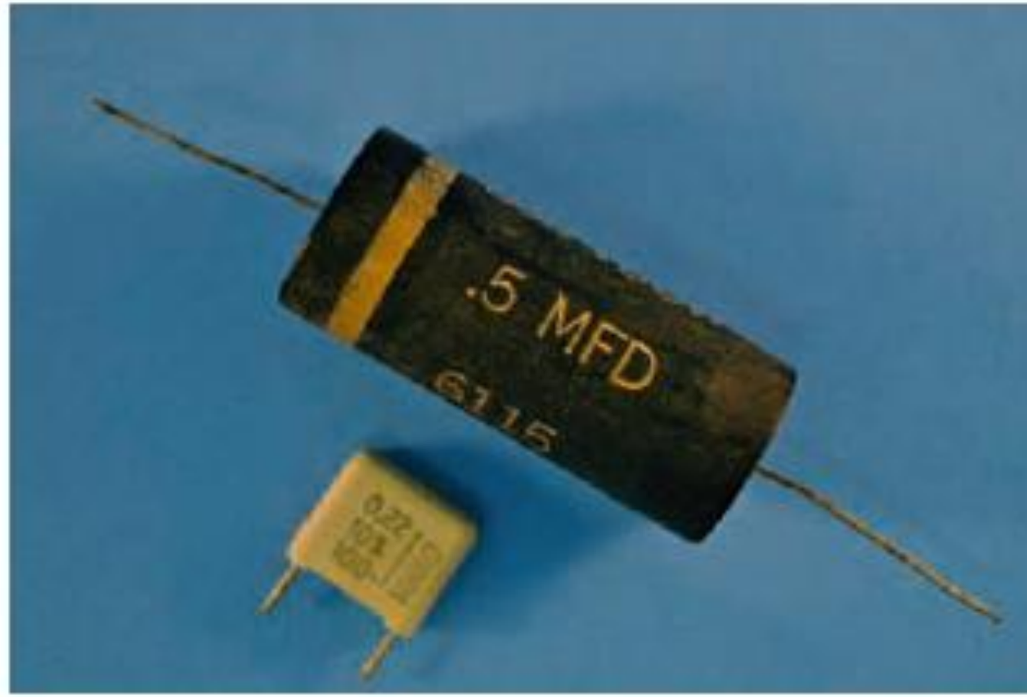


Fig 11-4. Paper and plastic capacitors.

Fig 11-3. Electrolytic capacitors.

Capacitors (cont'd.)

Fig 11-5. Ceramic disk capacitors.

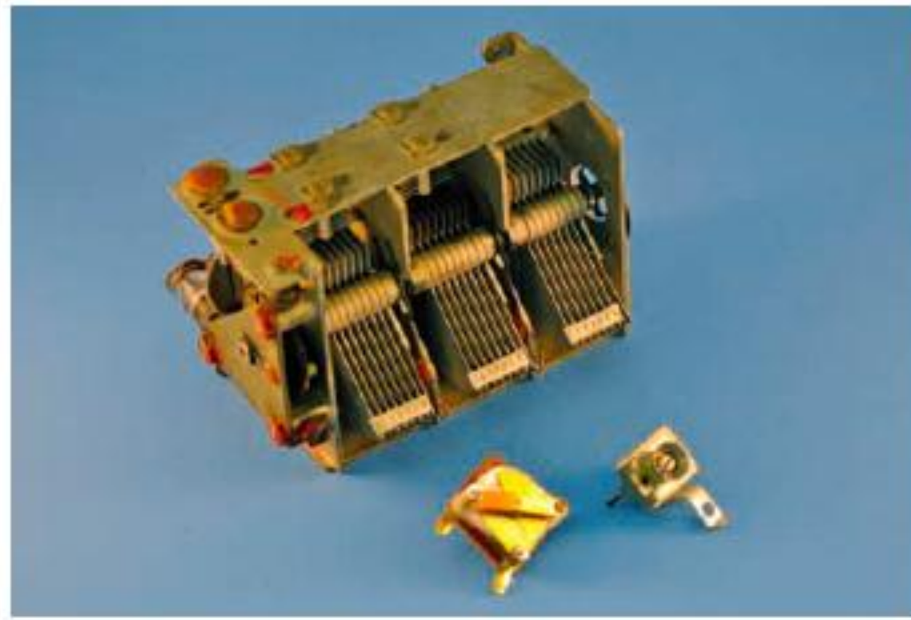


Fig 11-6. Variable capacitors.

Capacitors (cont'd.)

- Total capacitance in series circuits:

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \ldots + \frac{1}{C_n}$$

- Total capacitance in parallel circuits:

$$C_T = C_1 + C_2 + C_3 \ldots + C_n$$

RC Time Constants

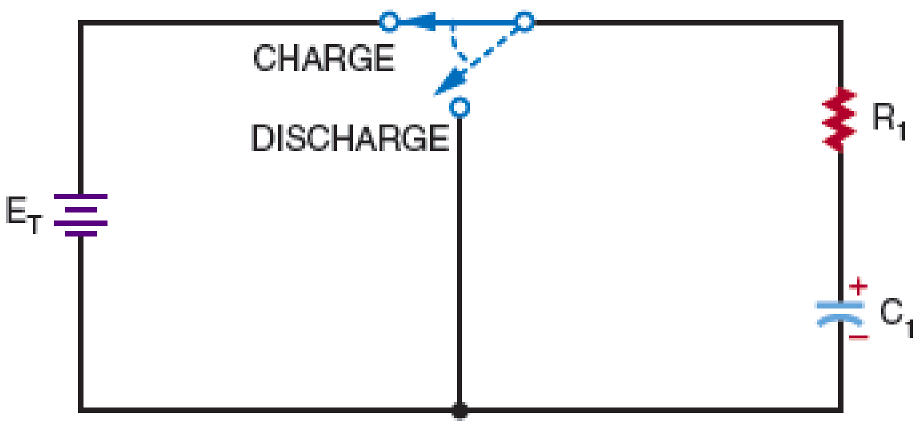


Figure 11-7. Circuit used to determine RC time constant

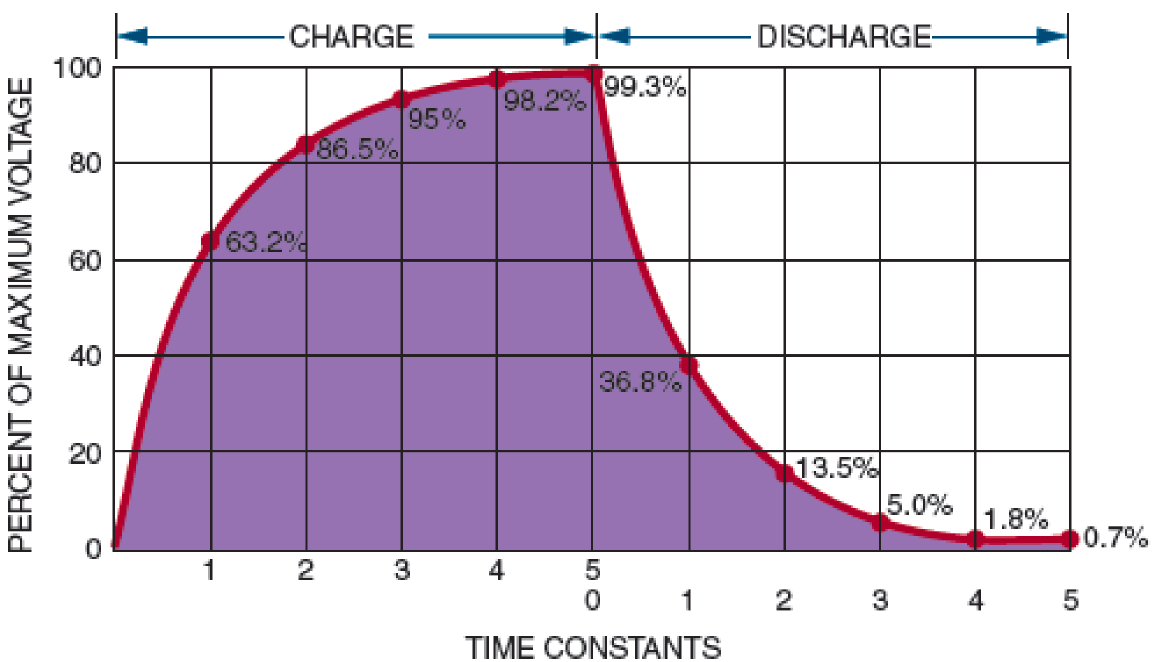
- RC circuit time constant formula:

  t = RC

  where: t = time in seconds

  R = resistance in ohms

  C = capacitance in farads



Summary

- Capacitance (*C*) allows for the storage of energy in an electrostatic field
- The unit of capacitance is the farad (F)
- Capacitor types include: electrolytic, paper, plastic, ceramic, and variable
- Total capacitance in series circuits:

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \dots + \frac{1}{C_n}$$

Summary (cont'd.)

- Total capacitance in parallel circuits:

$$C_T = C_1 + C_2 + C_3 \ldots + C_n$$

- RC circuit time constant formula:

$$t = RC$$

- It takes five constants to fully charge and discharge a capacitor