Chapter 3

Ohm's Law

Introduction

- *Ohm's law* is one of the most fundamental and important laws in the fields of electricity and electronics

Objectives

- Explain Ohm's law
- Use Ohm's law to determine voltage, current, or resistance
- Define energy and power
- Calculate power in a circuit
- Properly select resistors based on power considerations

Objectives

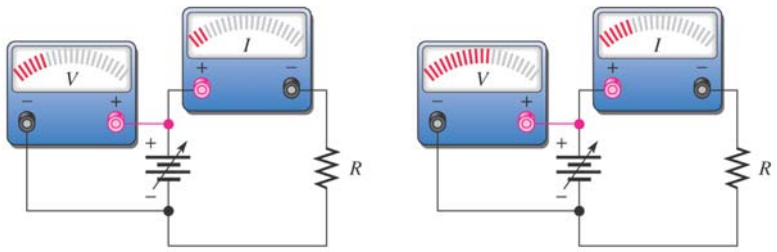
- Explain energy conversion and voltage drop
- Discuss power supplies and their characteristics
- Describe a basic approach to troubleshooting

Ohm's Law

- Ohm's law describes mathematically how voltage, current, and resistance in a circuit are related
  - if the voltage across a resistor is increased, the current through the resistor will increase
  - if the voltage is decreased, the current will decrease

Ohm's Law

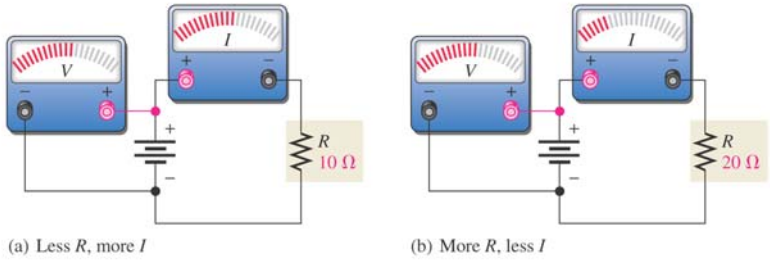
- The effect of changing voltage on current, if resistance is held constant



(a) Less V, less I (b) More V, more I

Ohm's Law

- The effect of changing resistance on current, if voltage is held constant



(a) Less R, more I (b) More R, less I

Formula for Current

- If the values of Voltage and Resistance are know, Current can be calculated as:

$$I = V/R$$

  - voltage must be in volts, and resistance must be in ohms in order to get current in amperes

Formula for Voltage

- If the values of Current and Resistance are know, Voltage can be calculated as:

$$V = IR$$

Formula for Resistance

- If the values of Voltage and Current are know, Resistance can be calculated as:

$$R = V/I$$

Energy and Power

- Energy is the ability to do work
  - Energy is measured in **joules (J)**
- Power is the rate at which energy is used

$$\mathbf{P = W/t}$$

  - **One watt (W) is the amount of power when one joule of energy is used in one second**

Energy and Power

- Typical power rating in watts for several household appliances

APPLIANCE	POWER RATING (WATTS)
Air conditioner	860
Blow dryer	1300
Clock	2
Clothes dryer	4800
Dishwasher	1200
Heater	1322
Microwave oven	800
Range	12,200
Refrigerator	1800
Television	250
Washing machine	400
Water heater	2500

Power in an Electric Circuit

- Power in an electric circuit may be expressed as:

$$\mathbf{P = VI}$$

- Using Ohm's law, and substituting, we can also obtain:

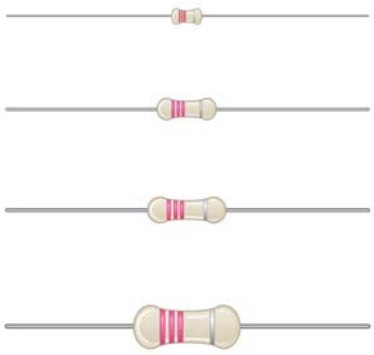
$$\mathbf{P = I^2R} \text{ and } \mathbf{P = V^2/R}$$

The Power Rating of Resistors

- The power rating is the maximum amount of power that a resistor can dissipate without being damaged by excessive heat buildup
  - The power rating is not related to the ohmic value
  - Power rating is determined by physical composition, size, and shape of the resistor

The Power Rating of Resistors

- Metal-film resistors are available in standard power ratings from 1/8 W to 1 W
  - When a resistor is used in a circuit, its power rating should be greater than the maximum power that it will have to handle

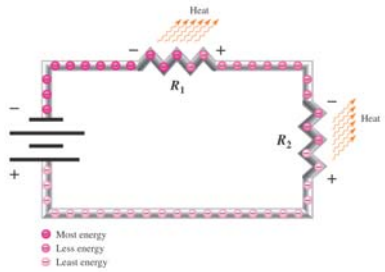


The Power Rating of Resistors

- When the power dissipated in a resistor is greater than its rating, the resistor will become excessively hot
  - the resistor may burn up
  - its resistance value may be greatly altered
  - damaged resistors may be detected by charred or altered appearance of the surface, otherwise a suspect resistor should be removed from the circuit and checked with an ohmmeter

Energy Conversion and Voltage drop in a Resistance

- As electrons flow through each resistor, some of their energy is given up in the form of heat
- The same number of electrons flow at each point throughout the circuit, but their energy decreases as they move through the resistance of the circuit



Power Supplies

- A power supply produces voltage across its output terminals and provides current through the load
  - The product IV_{OUT} is the amount of power produced by the supply and consumed by the load
  - A battery is a dc power supply that converts chemical energy into electrical energy

Power Supplies

- Ampere-hour ratings of batteries
  - Batteries have a certain capacity that limits the amount of time over which they can produce a given power level; this capacity is measured in ampere-hours (Ah)
    - Ampere-hour rating determines the number of hours a battery can deliver one ampere
    - Ampere-hour rating can also describe the number of amperes a battery can supply to a load for one hour

Power Supplies

- Electronic power supplies normally convert 110 VAC (volts alternating current) from a wall outlet into a regulated dc (direct current) voltage at a level suitable for electronic components
  - A regulated voltage is one that remains essentially constant with changes in input voltage or load

Power Supplies

- Efficiency of a power supply is the ratio of the output power P_{OUT} to the input power P_{IN}
  - Output power is always less than input power because some of the total power is used internally to operate the power supply circuitry
  - Internal power dissipation is called the power loss:

$$\mathbf{P_{OUT} = P_{IN} - P_{LOSS}}$$

Voltage Measurements

- To measure voltage, the voltmeter is placed in parallel across the component; that is, one lead is place on each side of the component

Resistance Measurements

- To measure resistance, the ohmmeter is connected across a component; however, the the voltage must be first disconnected, and usually the component itself must be removed from the circuit

Current Measurements

- To measure current, the ammeter must be placed in series with the component; that is, it must be in line with the current path

Summary

- Voltage and current are linearly proportional
- Ohm's law gives the relationship of voltage, current, and resistance
- Current is directly proportional to voltage
- Current is inversely proportional to resistance

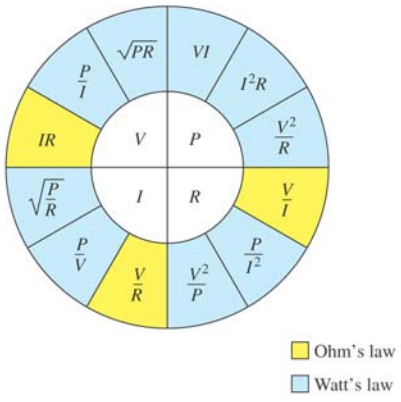
Summary

- A kilohm (kΩ) is one thousand ohms
- A Megohm (MΩ) is one-million ohms
- A microampere (μA) is one-millionth of an ampere
- A milliampere (mA) is one-thousandth of an ampere

Summary

- Use: V = IR, when calculating voltage
- Use: I = V/R, when calculating current
- Use: R = V/I, when calculating resistance

Summary



Summary

- Power rating is not related to resistance value
- Energy is equal to power multiplied by time
- Kilowatt-hour is a unit of energy
- A power supply is an energy source used to operate electrical and electronic devices
- A battery converts chemical energy into electrical energy
- Electronic power supplies convert commercial energy (ac) to a regulated dc voltage

Summary

- A load is a device that draws current from the power supply
- Capacity of a battery is measured in ampere-hours (Ah)
- Ampere-hours equals the number of hours a battery can supply one ampere, or the number of amperes a battery can supply in one hour
- Electronic power supplies require more power input than they can provide as power output