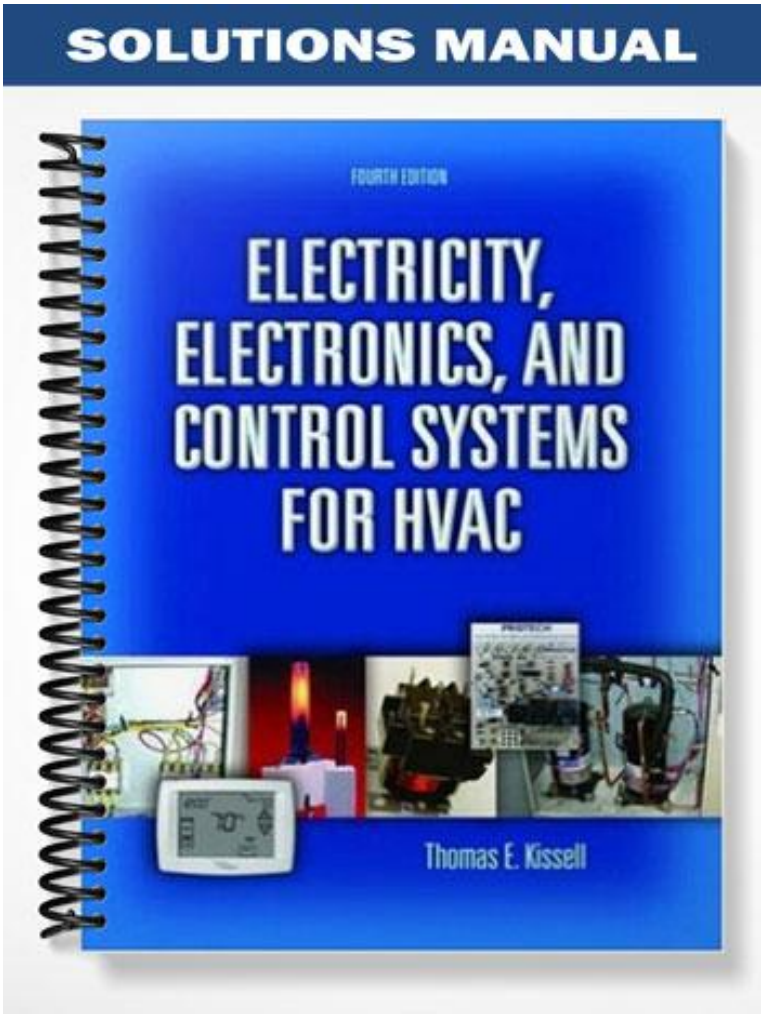
SOLUTIONS MANUAL



CHAPTER 2

FUNDAMENTALS OF ELECTRICITY

Job Assignment for This Chapter:
You are on a service call and a customer does not understand the basic theory of electricity and thinks you are trying to sell parts that are not needed. Your job is to use you knowledge of basic electricity and meters and explain how you can use your meter to test any of the switches in this system and how you can tell if they are good or bad.

Solution to the Job Assignment
Your solution should include basic statement about how current flows in a circuit. You should feel comfortable using terms such as voltage, current and resistance. You should be able to explain that meters can measure voltage, current and resistance and that if a circuit has a bad part, the current will not flow through it and the circuit will not operate correctly. You should also be able to explain that you could use a meter to test any switches that you thought were bad.

OBJECTIVES

After reading this chapter, you will be able to:

1. Explain the term *electricity*.
2. Describe the term *voltage*.
3. Explain the term *current*.
4. Describe the term *resistance*.
5. Understand the sources of electricity.
6. Understand Ohm's law.
7. Explain the difference between rechargeable and non rechargeable battery.
8. Explain the term milli.
9. Explain the term Mega
10. Explain the term Micro
11. Explain the term kilo

TERMS YOU WILL LEARN IN THIS CHAPTER

Alternating Current (AC) Current that changes from a positive level to a negative level periodically. Its waveform is a sine wave. Example: A 60-Hz alternating current changes from positive to negative 60 times per second and has a frequency of 60 Hz.

Ammeter An instrument that measures electrical current in amperes

Atom A unit of matter, the smallest unit of an element that consists of an nucleus that has a positive charged protron and neuatral charged neutron. The atom also has one or more negative charged electrons that moves about the nucleus in an orbit.

Clamp on Ammeter An ammeter that has a set of "jaws" that open to allow them to wrap around a wire. The jaws close around the wire and function as a transformer coil to sense the amount of current flowing through the wire. The clamp on ammeter is a non-contact type meter that can quickly clamp around a wire that you want to measure the current flow of.

Conductor A wire that is usually made of copper or aluminum that carries electrical current.

Current The flow of electrons that is measured in amperes.

Direct Current (DC) Current that flows in only one direction. Batteries are one power source of direct current

Electrical control The switches in a schematic or wiring diagram that provide the sequence turn loads on or off.

Electrical load The devices in an electrical system that consume energy and convert it to motion, heat or light. Typical loads in an HVAC system include indicator lamps, fan motors, compressor motors, electrical heating coils, and solenoid, relay and motor starter coils.

Electrical Potential Voltage that provides electrical force in a circuit.

Electrical Power The energy in an electrical circuit that is the result of voltage and current. The units of electrical power are watts.

Electricity The flow of electrons

EMF (Electromotive Force) Another term for voltage, or potential difference.
Electromotive Force

Insulator A material that does not conduct electrical current easily. These materials have very high resistance. In electronics, an insulator material has 5, 6 or 7 electrons in its valence shell.

Neutron The neutral part of the atom. The neutron is located with the proton as part of the nucleus of the atom.

Nucleus The center of an atom that consists of protons and neutrons.

Ohmmeter A meter that is designed to measure resistance and indicate the value in ohms. A high ohms reading is indicated as infinity.

Ohm's Law A set of mathematical calculations that show the relationship between voltage, resistance, and current. Voltage is equal to the amount of resistance multiplied by the amount of current.

Proton The positive part of an atom. The proton is located with the neutron in the nucleus of the atom.

Resistance The opposition to current flow. The units of resistance is Ohms.

Static Electricity The electrical charge that is caused by the inbalance of positive and negative charges. Static electricity can be created by rubbing two non conductive materials together and then drawing them apart slightly.

Voltage The electromotive force or pressure in an electrical circuit that causes electrons (current) to flow.

Watts The units of electrical power.

QUESTIONS

1. Define the term *electricity*. **Electricity is the flow of electrons**
2. What is voltage? **Voltage is the force that causes electrons to move as current**
3. What is current? **Current is the flow of electrons.**
4. Explain what a valence electron is and why it is important to current flow. **The valence electron is all electron in the outer most orbit (shell) around the nucleus.**
5. What is resistance? **Resistance is the opposition to the flow of electrons.**
6. Define the term *power*. **Power is the work electricity can do. It is calculated by multiplying current times voltage.**
7. Explain the term *infinite resistance*. **Infinite resistance is a value that represents an amount of resistance that is too high for the meter to read. Infinite resistance is typically caused by an open in a wire fuse or switch**.
8. Explain how magnetism is created in a coil of wire. **When current flows through a coil of wire, flux lines are created which creates a magnetic field. As current is increased, the magnetic field becomes stronger.**
9. What is EMF? **Electromotive Force (voltage)**
10. What is the unit for power? **Watts**
11. What is static electricity? **The electrical charge that is caused by the inbalance of positive and negative charges. Static electricity can be created by rubbing two non conductive materials together and then drawing them.**

TRUE OR FALSE

1. **TRUE** The insulation coating on wire has high resistance.
2. **FALSE** Voltage is the flow of electrons.
3. **TRUE** Resistance is the opposition to current flow.
4. **FALSE** Watts are the units for current.
5. **TRUE** A good conductor has low resistance.
6. **TRUE** The negative part of an atom is an electron.
7. **TRUE** Milli is the prefix for 1/1000
8. **TRUE** A battery creates voltage from a chemical reaction.
9. **TRUE** Voltage is pressure that causes current to flow.
10. **TRUE** Kilo is the prefix for one thousand (1000).

MULTIPLE CHOICE

1. A valence electron is _____**b**_____.
   a. the electron closest to the nucleus.
   b. **the electron in the outermost shell.**
   c. an electron with a positive charge.

2. Wattage is ____**a**_____.
   a. **the unit for power.**
   b. the unit for current.
   c. the unit for voltage.

3. Resistance is ____**c**_____.
   a. the force that moves electrons.
   b. wattage.
   c. **the opposition to current flow.**

4. Current will ____**a**_____ when voltage increases and resistance stays the same.
   a. **increase**
   b. decrease
   c. stay the same

5. Wattage will _____**a**_____ when voltage increases and current stays the same.
   a. **increase**
   b. decrease
   c. stay the same

6. A milliamp is _____**a**_____.
   a. **one-thousandth of an ampere.**
   b. one-millionth of an ampere.
   c. one million amps.

7. Like charges __**b**____
   a. attract
   b. repel
   c. have no affect on each other

8. The atom has which of the following parts__**e**__?
   a. electron
   b. proton
   c. neutron
   d. nucleus
   e. all the above

9. A load is _____**a**_____.
   a. **the part of a circuit that has resistance**.
   b. a switch in a circuit that controls current flow.
   c. a power source for a circuit.

10. A conductor is _____**b**_____.
    a. a material that stops the flow of electrons.
    b. **a material which allows electrons to flow easily**.
    c. provides a source of voltage for a circuit.

11. A control is _____**b**_____.
    a. the part of a circuit that has resistance.
    b. **a switch in a circuit that controls current flow.**
    c. a power source for a circuit.

Problems

1. Use Ohm's law to calculate the amount of voltage if current in a DC circuit is 5 A and resistance is 8 Ω.
   40 VOLTS (5A x 8 ohms = 40v)
2. Use Ohm's law to calculate the amount of current in a DC circuit if voltage is 25 V and resistance is 50 Ω.
   I = E/R I = 25V/50 ohms I=0.5 amps
3. Use Ohm's law to calculate the amount of resistance in a DC circuit if voltage is 40 V and current is 10 A.
   R=E/I R=40V/10A R=4 ohms
4. Use the power formula to determine the wattage in Problem **P=IxE P=5Ax40V P=200 Watts**
5. Use the power formula to determine the wattage in Problem 2.
   P=IxE P=25V x 0.5A P= 12.5 Watts
6. Use the power formula to determine the wattage in Problem 3.
   P=IxE P=40V x 10A P= 400 Watts
7. Calculate the BTU output for an electric heating element that is rated for 10 Watts
   1 watt = 3.413 BTU 10W=34.13 BTUs
8. Calculate the number of Watts in 10 hp
   1HP = 746 Watts 10 HP = 7460 watts
9. Calculate the Watts output of the electric heating element that draws 10 amps and uses 220 V.
   P=Volts X Amps P= 10 x 220 P=2200 watts
10. Calculate the total amperage draw for an air conditioning condenser that has a fan motor that uses 3.5 amps and a compressor motor that uses 12 amps.
    Total amps = Motor 1 + Motor 2 Total amps = 3.5amps + 12 amps Total amps =15.5 amps

CHAPTER 3

ELECTRICAL CIRCUITS

Job Assignment for This Chapter:
A customer has a question about why a fuse continues to blow on their outdoor air conditioning that contains the compressor and condenser fan. Explain to this customer the function of a fuses and how it protects both motors when it blows. You should also be able to explain to the customer how the fuse is connected in series with the fan motor and compressor and they are connected in parallel with each other. You should also be able to give the customer some ideas of how you could tell which component in the circuit is causing the circuit to draw more current than the fuse is rated for.

Solution to the Job Assignment:
Your solution should include information about the difference between a series and parallel circuit. You should be able to explain that the fuse is in series with all of the loads in the circuit. You should be able to explain how the compressor and the condenser fan both have current ratings posted on them. You can explain to the customer that you can put an ammeter on each device and see which one has exceeded its rating. Since you have not had information about meter yet, you are not expected to know how to take a current reading, just that a current reading should be made. Since the fuse is in series with both motors, if either motor is going bad and draws more current than it should and it will cause the main fuse to blow.

OBJECTIVES

After reading this chapter, you will be able to:

1. Explain the operation of switches that are connected in series.
2. Explain the operation of electrical loads that are connected in series.
3. Explain the relationship between voltage, current, resistance and power in a series circuit.
4. Utilize Ohm's law for series circuit calculations.
5. Explain the relationship between voltage, current, resistance and power in a parallel circuit.
6. Use Ohms Law to calculate the voltage, current, resistance, and power in a parallel circuit.
7. Explain the operation of loads, such as motors, connected in parallel.
8. Explain the operation of switches connected in parallel.
9. Explain the relationship between switches and loads that are connected in series- parallel.
10. Calculate the voltage, current, resistance, and power in a series-parallel circuit.