Electric Circuits & Components

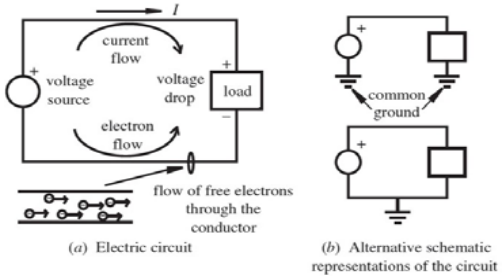


Figure 2.1 Electric circuit terminology

Basic electric elements

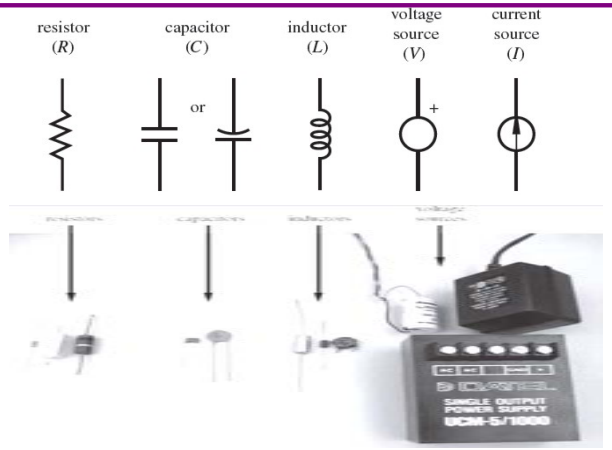


Figure 2.2 Basic electric elements

Resistor

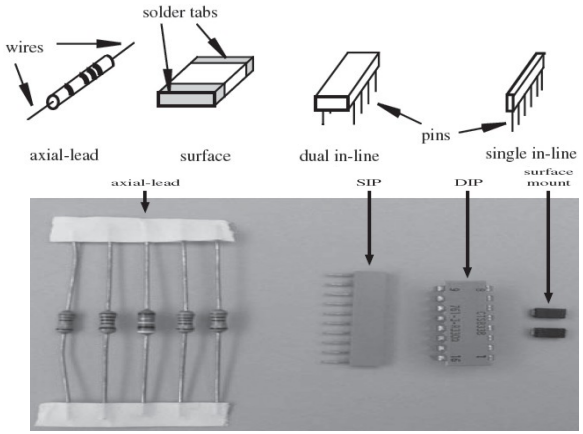


Figure 2.3 Basic electric elements

Resistor: Potentiometer

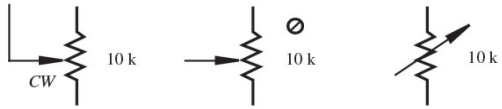


Figure 2.4 Potentiometer Symbol

Figure 2.5 Common Potentiometers

Capacitor & Inductor

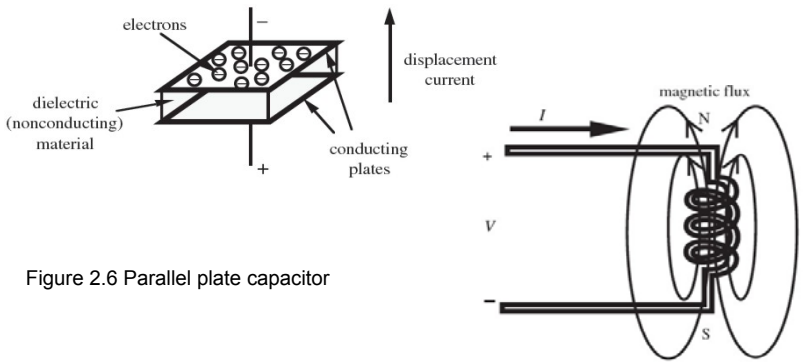


Figure 2.6 Parallel plate capacitor

Figure 2.7 Inductor

Kirchoff's Law: Voltage Law (KVL)

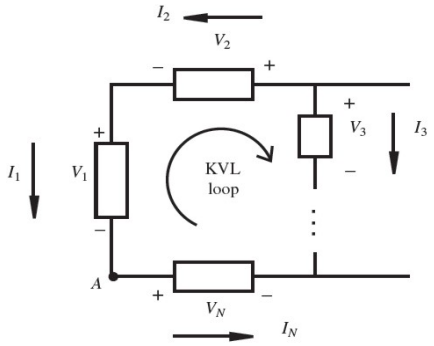
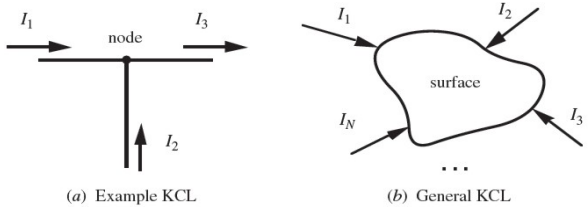


Figure 2.8 Kirchoff's Voltage Law

Kirchoff's Law: Current Law (KCL)



(a) Example KCL (b) General KCL

Figure 2.9 Kirchoff's Current

Kirchoff's Law:

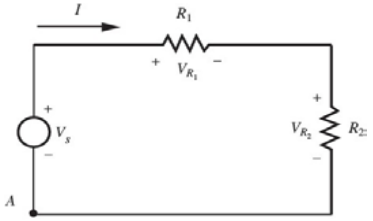


Figure 2.10a Series resistance circuit

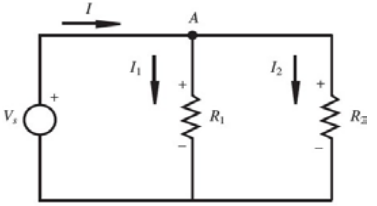


Figure 2.10b Parallel resistance circuit

Voltage/Current source

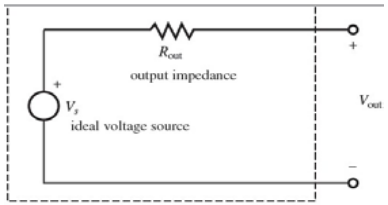


Figure 2.11a Real voltage source

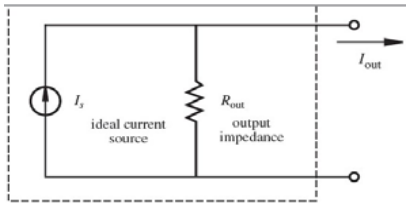
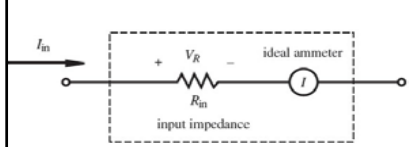


Figure 2.11b Real current source

Ammeter/voltmeter



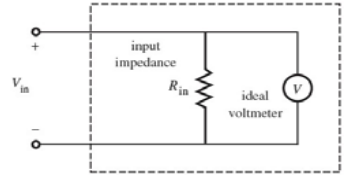
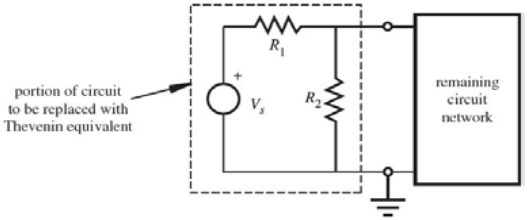
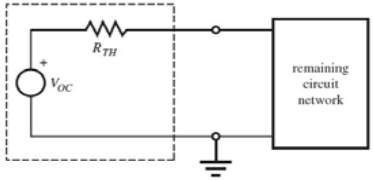


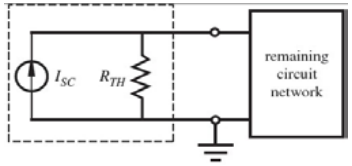
Figure 2.12 ammeter/voltmater

Thevenin/Norton equivalent circuit





Thevenin eq circuit



Norton eq circuit

AC current

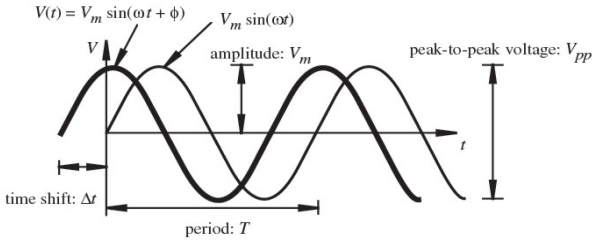


Figure 2.14 Sinusoidal wave form

Electrical Safety

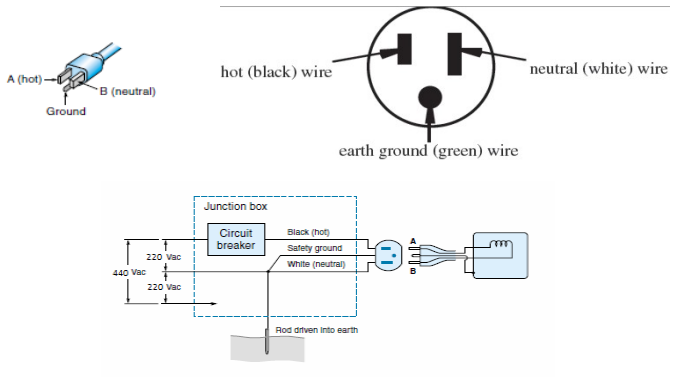


Figure 2.15 Three- prong AC power plug

Electrical Safety

- The power company maintains the voltage of prong B at ground, which means it is not only the return path for the current but also is actually connected to a metal rod driven into the earth. Therefore, the wire that goes to the wide prong (B) is called the **neutral, return wire** or *cold side* (usually white in color)
  - theoretically safe to touch. (However, this is not recommended because it could be wired wrong!)
- The wire going to prong A is called the *hot side* because it carries the voltage (usually black in color and should definitely *not* be touched!).
- The third pin on the plug is the *safety ground*
  - kept separate from the neutral wire until the actual grounding point.
  - This ground wire is typically connected to the chassis or motor frame, which prevents you from getting a shock from touching the equipment because it is at the same potential as the earth.

Electrical Safety

- Electricity can injure, permanently disfigure, or kill human beings.
- Strictly speaking, it's not the voltage but the current that does the damage.
- Large currents, above 2 amps, literally cook the flesh, causing severe burns.
- Currents between 1 and 2 amps damage nerve centers, can cause temporary or permanent paralysis, and may be lethal if the heart is involved.
- A current in the range of 100–200 mA causes the muscles to flutter uncontrollably; here again, if the heart is involved, it stops working properly. This is probably the most common form of death by electrocution.
- Currents from 25 to 75 mA may cause unconsciousness.
- Currents around 25 mA tend to make the muscles contract and "lock up" (a horrible situation because the victim can't let go).
- Even smaller current shocks are dangerous, because they can cause a person to jump or lurch violently and perhaps hit something or fall.

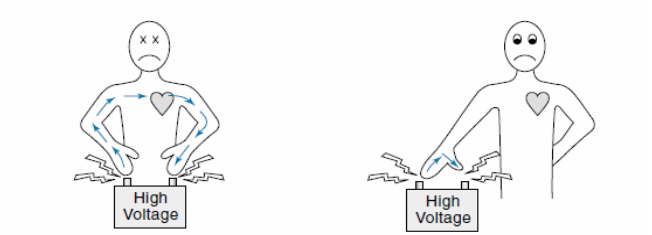
Electrical Safety

How does current enter the body?

- By touching two different electrical potentials at the same time (usually the high voltage and ground).
- In such a case, the body completes the electric circuit and current flows.
- The resistance of dry skin is high enough so that a person doesn't even start to feel a shock until around 50 V; but by 120 V a painful shock is felt.
- Wet skin offers less electrical resistance, so any voltage delivers more of a shock if the skin is wet.
- Two examples of a person being shocked are shown in Figure 2.16.
  - In Figure 2.16(a) the man is touching the voltages with both hands, so the current path goes near his heart—a very dangerous situation.

Electrical Safety

– If you work around high voltages, it is much safer to use only one hand as shown in Figure 9.7(b), because the probable current path is then far away from the heart.



(a) When voltage is touched with both hands, current goes through the heart

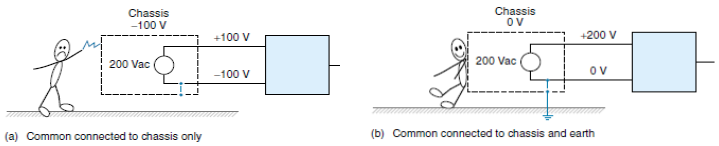
(b) When voltage is touched with one one hand, current is away from the heart

Figure 2.16 Issues in electrical safety

Electrical Safety

- Electrical safety depends on two things:
  - safe equipment and safe practices.
- Safe equipment means that all high voltage surfaces are covered in some way to prevent accidental contact.
  - In high-voltage areas, placing rubber mats on the floor and using of rubber gloves and nonconductive fiberglass ladders (if needed) will reduce the possibility of personnel getting shocked.
  - All chassis, cases, and surrounding metal (as well as the neutral power line) should be well connected to earth ground. This promotes safety, because if a high-voltage line got loose and somehow touched the case (or developed a "short" to the case), the resulting current would be dumped to ground, but the case itself would stay at a safe ground voltage (as illustrated back in Figure 3.43).

Electrical Safety



(a) Common connected to chassis only

(b) Common connected to chassis and earth

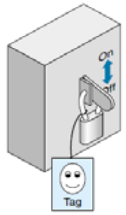
Figure 2.17 Connecting the signal common to an earth ground for safety.

- People who work around high voltages must follow some basic safety rules:
  - 1. *Always turn off the power before you work on the equipment.*
  - 2. If equipment can't be unplugged (for example, a huge printing press occupying many square feet), then be sure its power feed line goes through a switch box that can be padlocked in the off position [see Figure 9.7(c)] Before you work on the equipment, you would lock the switch in the off position and put a paper tag on the switch stating who you are and letting people know that you are in there working on the equipment. When you are finished working, you remove your tag and lock. No

Electrical Safety

People who work around high voltages must follow some basic safety rules:

1. *Always turn off the power before you work on the equipment.*
2. If equipment can't be unplugged (for example, a huge printing press occupying many square feet), then be sure its power feed line goes through a switch box that can be padlocked in the off position.
3. Even if you have turned the power off at the master switch, there is always the possibility that you locked the wrong switch or that it is miss-wired. To be sure, you should actually measure the high-voltage line with a meter (or two different meters) to confirm that the power really is off.



(c) Switch box that can be padlocked in the off position

4. Once you have verified that the power is off, you can temporarily jumper the high voltage line to ground, which will protect you should someone, somehow, turn the power back on before you are finished. (However, this practice is appropriate only if there are protective relays in the line that will open when there is a short circuit.