PV101 Solar Fundamentals Online Course

Soofka Continuing Education Services

PV 101 Learning Objectives

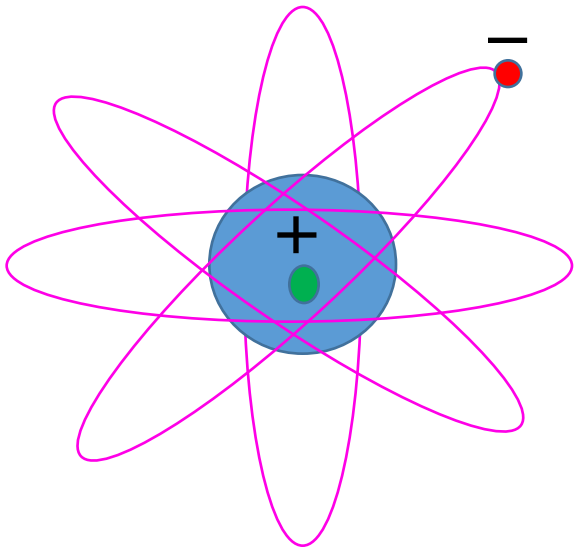
Basic Electricity and Electrical Safety – This Module covers basic concepts of electricity and the important safety considerations that must be followed to prevent job site accidents and injury.

- Basic Electricity
- Potential Energy – Batteries
- Resistance Power – Heat
- The Human Body – Effects of Electricity
- Photovoltaic Cells – Series and Parallel Circuits

Basic Electricity

What is Electricity? We all know that it is what provides the energy to power our lights and appliances.

But where does it come from and how does it behave? While we do not want to go deeply into the physics and mathematics here, we do have to start with the atom which is the basic building block of all materials or matter which exist in our universe.

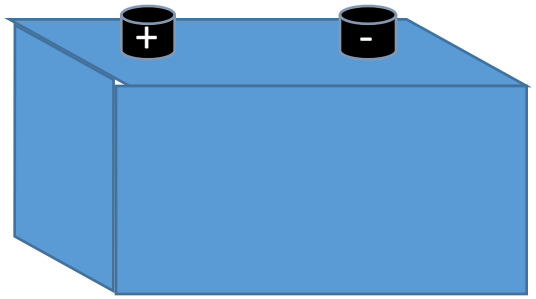


The electron is a negatively charged particle that orbits the atom.

The atoms of some materials have free electrons that can travel from one atom to the next. These materials are **conductors** such as copper.

Other materials do not have free electrons. These materials are **insulators** such as rubber.

Potential Energy - Batteries



You can think of the energy stored in a battery as potential energy that can be used for work, light or heat.

Batteries have two important ratings:

- Voltage
- Capacity

- The voltage can be the same for batteries of different sizes.
- A battery's **capacity** is the amount of electric charge it can deliver at the rated voltage.
- Capacity is measured in Ampere-hours.
- A larger battery generally has a greater capacity.

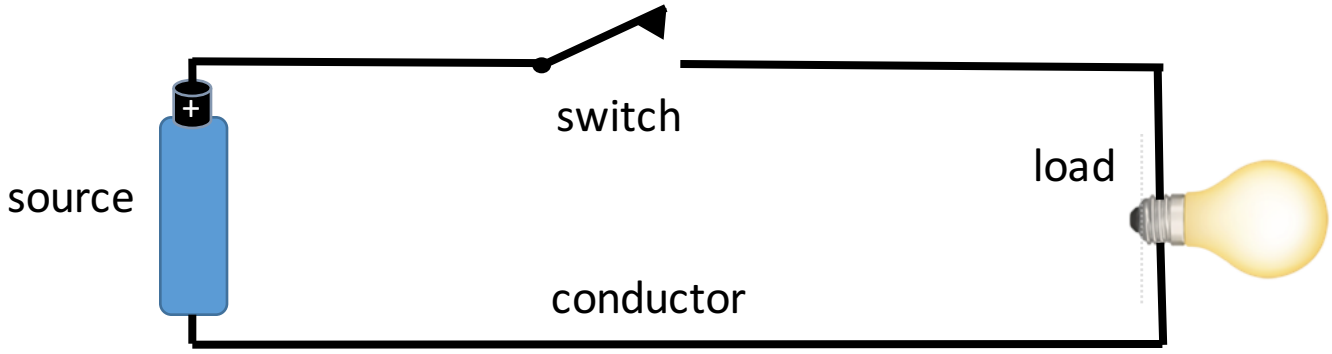
So common sense will tell you that while you may be able to touch the positive and negative terminals of a small battery cell designed for toys and flashlights without danger. However, this is **not** true for larger batteries such as those for automotive applications. And when it comes to industrial sized batteries that may be used in larger scale PV installations the danger is quite real.

Potential Energy - Batteries

As a matter of fact there is a potential danger even in small batteries! Let's get in a few more definitions to help with the explanation.

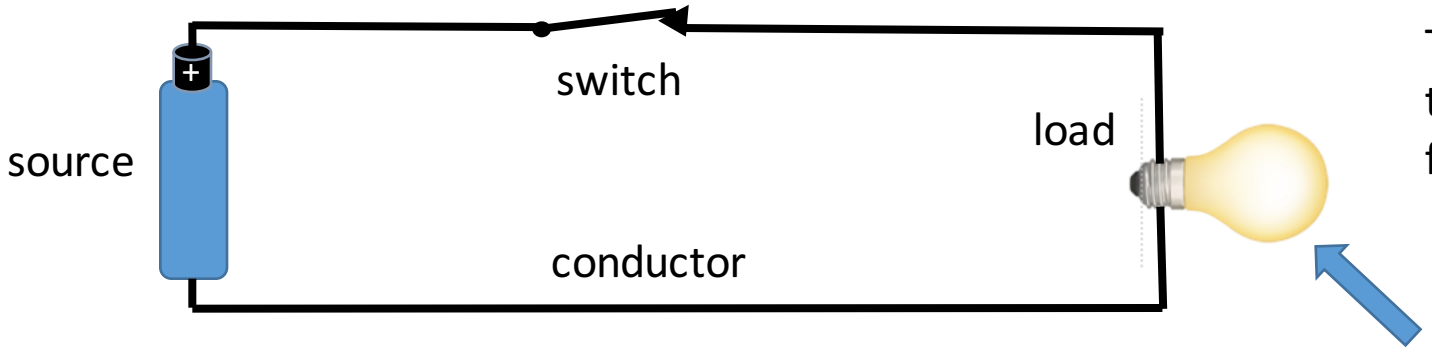
- Amperes – is the measure of current based the number of electrons moving past a point in a circuit.
- Circuit - is the path in which electrons flow.

An electrical circuit generally contains a source, conductor, switch and a load.



This is an "**open circuit**" because the switch is open and no current is flowing.

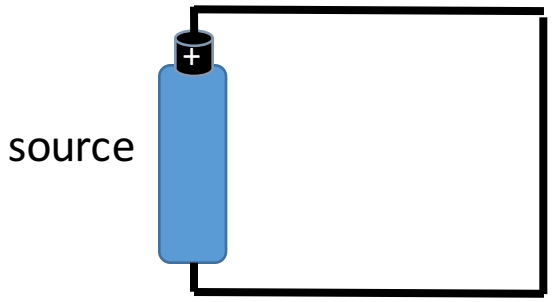
Potential Energy - Batteries



This is an "**closed circuit** " because the switch is closed and current is flowing.

The load is the part of the circuit that uses the energy for work, light or heat.

So what happens if there is no load?



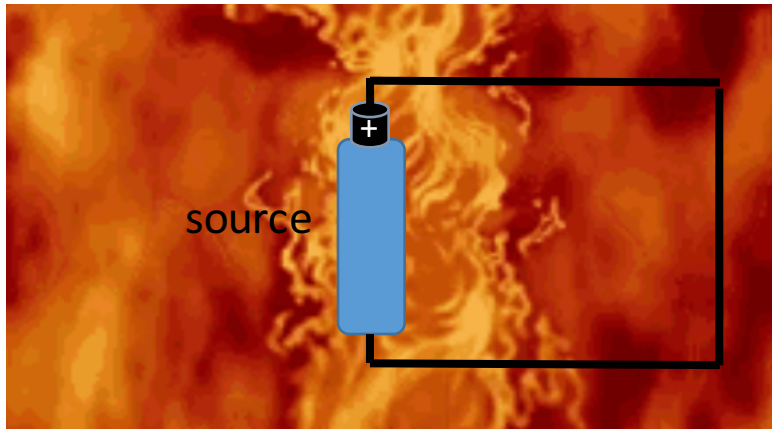
This is a "**short circuit**" when you have no load in the path to use or dissipate the energy.

Potential Energy - Batteries

So what happens if there is no load?

The current will flow fast and furious and the battery will rapidly heat up!

- All batteries have a small amount of internal **resistance** which is not enough to dissipate all that energy.



- The battery certainly will be destroyed.
- Potentially toxic substances are likely to leak from the battery.
- There is potential for fire and possible explosion even from small household batteries when they are short circuited.

Care must be taken to prevent accidental short circuits of batteries!

General Battery Safety Mandates

Take care that the polarity is correct when installing.

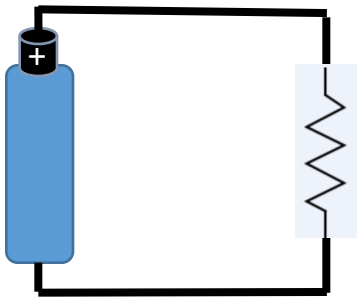
Take care not to allow batteries to become too hot, both when in storage and while installed.

- Follow the manufacturer's guide lines with regard to temperature.
- Enclosures should be well ventilated or even cooled in extreme environments.

Do not use batteries that are damaged in any way.

- Batteries should always be treated as hazardous waste and recycled by waste management professionals.

Resistance Power & Heat



Voltage Source

Resistor or load

In basic electronics instruction the load is represented by a resistor.

Ohms Law is the basic calculation to describe the relationship between Voltage, Current and Resistance.

$$\frac{V}{I} = R$$

$$I\,X\,R = V$$

$$\frac{V}{R} = I$$

A resistor dissipates energy in the form of heat. $I^2 x\ R = Power$

The unit of power is Watts which is defined as: Power is the rate at which energy is generated or used and is measured in units (e.g. watts) that represent energy per unit time.

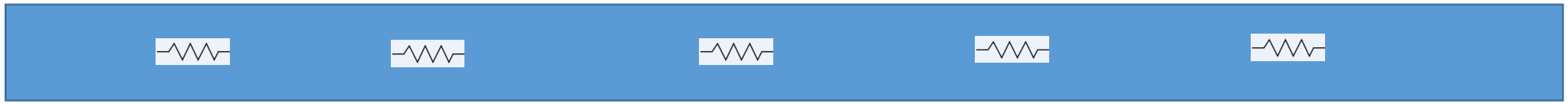
Resistance Power & Heat

So resistance dissipates energy in the form of heat. We saw this in the example of a short circuited battery. Its small internal resistance generated heat.

- An ideal conductor would have zero resistance and dissipate no heat.

While we would like all components to be ideal this is not the case.

- Wire and electrical cables always have a small distributed resistance which adds up as the length of the cable increases.



Resistance Power & Heat

The resistance of a conductor changes with the diameter of the conductor - thicker wires have less resistance to current flow than thinner wires, the resistance of a conductor also changes with changing temperature.

The cable used with a 240V home charger is much smaller and takes 6-8 hours to charge the battery in this electric car.

These fast chargers in downtown Portland Oregon can charge the same car in a half an hour.

Notice the difference in the diameters of these cables.

Resistance Power & Heat

Another factor is that the resistance of a conductor increases with heat. This means that a cable not only needs to be rated for a certain voltage and current but also an ambient temperature range.

The Human Body

The Human Body – Safety considerations.

Left hand rule
PPE Insulated Gloves and shoes.
Water and wet equipment.
Keep terminals covered
Heat
PV – cover Voc always present

Photovoltaic Cells – Series and Parallel

The definition of
A solar cell, or **photovoltaic cell** converts light energy directly into electricity by the photovoltaic effect, the electrical characteristics, such as current, voltage, increase when exposed to light. Solar cells are the building blocks of solar panels.

In an electrical circuit or system solar cells perform in the same way as batteries with regard to Series and Parallel configuration.

Photovoltaic Cells – Series

Photovoltaic Cells –Parallel

The Human Body and Electricity