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Two types of grounds: Service and equipment grounding.

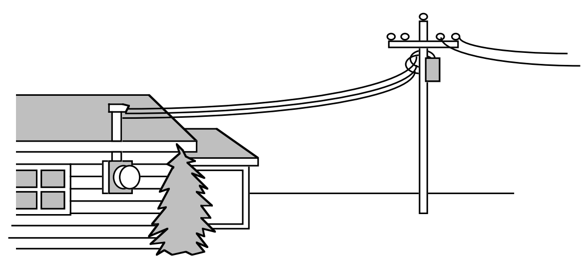
The **service ground** is the intentional grounding of one conductor of a system by connecting it to a grounding electrode.

The **equipment ground** bonds conduits, enclosures, and nonelectric equipment which is to be grounded to form a **continuous** path to a grounding electrode and provides a connection to the grounded conductor.

When a conductor or metal object is connected to an earth electrode, it is forced to take the same **zero** potential as the earth. Any attempt to raise or lower the voltage of the grounded object results in current passing over the connection until the potential of the object and the potential of earth are equal.

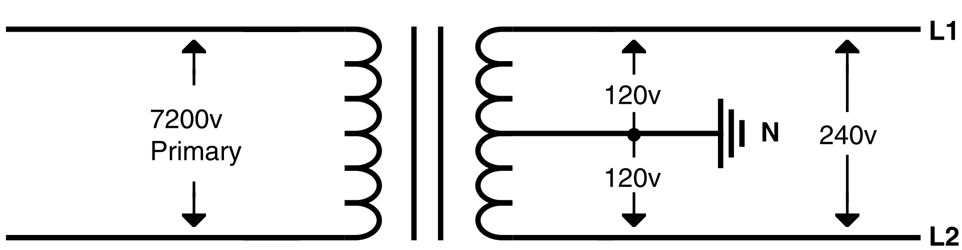
Grounding is a means for ensuring that a **grounded** object cannot take on a potential **differing** from earth's potential, which is zero.

For example: If a 7,200 volt primary line fell across a 240/120 volt residential service drop and the conductors crossed, or an accidental breakdown of the insulation in the transformer, and the primary and secondary cross, **without** grounding, the 240 volt secondary can assume the same high-voltage potential. This is a very hazardous condition.



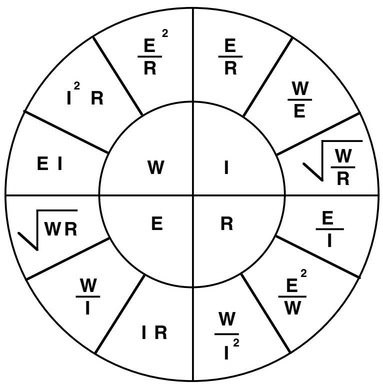
To guard against this hazard, the system is required to be effectively grounded. By connecting the neutral conductor to earth, no conductor of the grounded secondary circuit could have a potential greater than the normal circuit voltage.

The sketch below shows a 240/120 volt single-phase secondary. By grounding the neutral, a person could touch the neutral conductor without receiving a shock. Touching the L1 or L2 conductor while standing on a grounded object, would give you a shock, as there is a voltage potential between L1 and L2 to the grounded neutral.



To properly understand and install grounding, the electrician needs to understand AC reactance and how it applies.

Sometimes we get confused with all the words and terms used in the study of electricity. Electricity is one of the fundamental quantities in nature. Electricity was discovered, not invented. This chapter will help the electrician understand the meaning of these words.



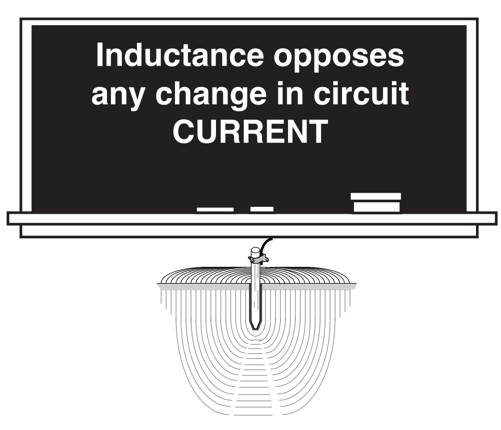
The Ohm's law circle actually applies to DC (direct current) pure resistance. AC (alternating current) has two components not found in a DC circuit that add opposition to the normal flow. These two components are called "inductive reactance" and "capacitive reactance."

As we have learned in theory, when an electric current moves through a wire, a magnetic field is formed around this wire. When the current in an electric circuit changes, the circuit may **oppose** the change. The property of the circuit that opposes the change is called **inductance**.

For a DC circuit, inductance affects the current flow when the circuit **is turned on or off**. When the switch is turned on, current flows through the circuit and the lines of magnetic force expand outward around the circuit conductors and the current rises from zero to its maximum value. Whenever a current flow changes, the induced magnetic field changes and opposes the change in current whether it be an increase or decrease and inductance will **slow down** the rate at which the change occurs. When the switch is opened in a DC circuit, the current will drop very rapidly towards zero causing the magnetic field to collapse and generate a very high voltage, which not only opposes the change in current but can also cause an arc across the switch.

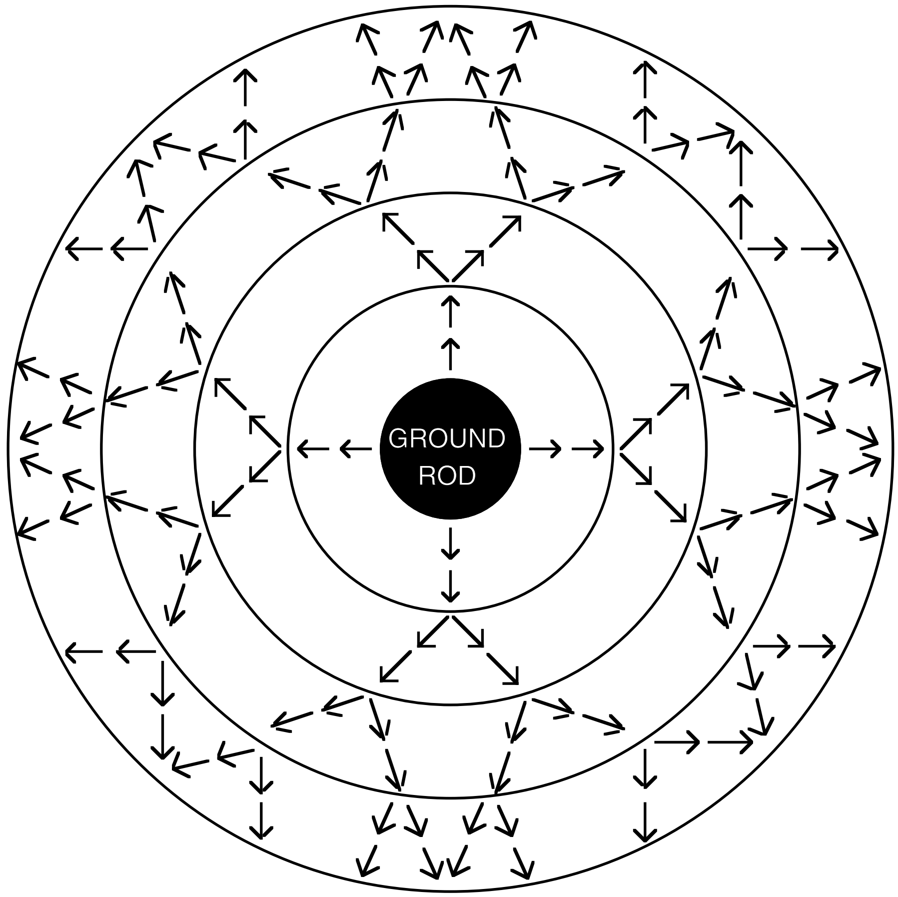
The big difference is an AC circuit is **constantly** switching on and off, reversing direction 60 times a second. So circuit inductance affects AC circuits **all the time**.

In an inductive circuit when current increases, the circuit stores energy in the magnetic field. When current decreases, the circuit gives up energy from the magnetic field. In an AC circuit, the magnetic field is always changing. Every circuit has some inductance, although it may be so small that its effect is negligible, even in an AC circuit.



The electrode is a path into earth for the electrons, the lower the resistance the better the path.

A ground rod driven into earth radiates current in all directions around the rod. Think of the ground rod as being surrounded by **shells of earth**, all of equal thickness.



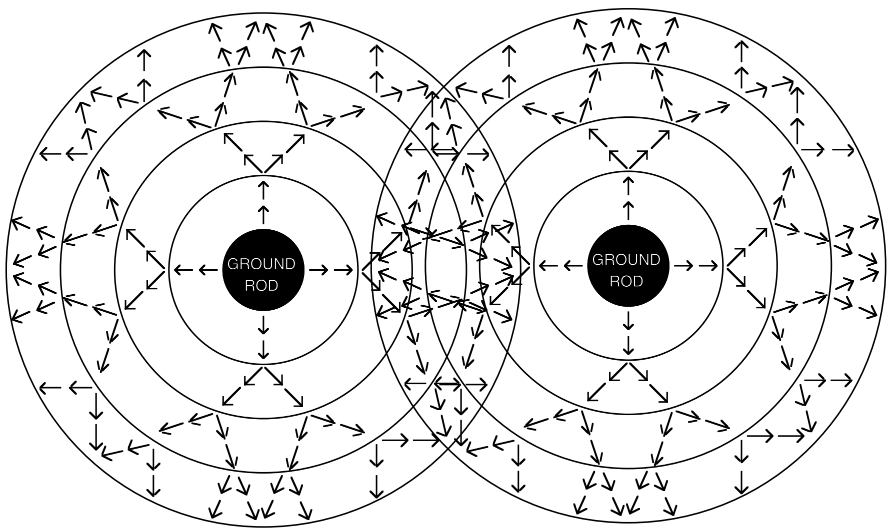
The earth shell nearest to the ground rod has the smallest surface area and offers the **greatest** resistance. The next earth shell is a little larger in area and offers **less** resistance. And each shell on out offers less resistance and so on. Eventually, a distance will be reached where additional earth shells hardly add any resistance to the earth surrounding the ground rod.

If the ground rod to earth resistance is not low enough, there are several ways you can improve it such as: lengthen the ground rod into earth, treat the soil, or use multiple ground rods.

Increasing the diameter of the ground rod has little effect on its earth resistance. Driving a longer ground rod deeper into the earth decreases the resistance. In general, doubling the ground rod length reduces resistance by aproximately 40%.

Two well-spaced ground rods driven into the earth provide parallel paths of resistance. The rule for two resistances in parallel does not apply exactly in this situation. The total resistance is not one-half of the individual rod resistance to earth. Actually, the reduction for two equal-resistance ground rods is about 40%. If three rods are used, 60%, and if four rods are used the reduction is 66%.

When using multiple rods, they must be spaced further apart than the depth they are driven. If spaced too close together as shown below, the earth shell resistance area will be overlapped causing a higher resistance.



If you had two ground rods connected in parallel spaced 10 feet apart, the resistance is lowered aproximately 40%. If the spacing is increased to 20 feet apart, the resistance is lowered to aproximately 50%.

The type of soil is a determining factor in deciding what type of electrode to use. Driven ground rods are generally more satisfactory and economical where rock is 10 feet or more below the surface. Buried plates, strips, grids, and concrete footings are used where rock is encountered at a shallow depth.

Earth conductivity varies with the type of soil, moisture and salt content, and seasonal temperatures. Soils can range from the poor hot dry sand to the moist black dirt. Clay, limestone, shale, sandstone, slate, granite, gravel, etc. are some of the types throughout the country.

Chemical treatment of the soil is a good way to improve the electrode-earth resistance. The **first few inches** away from the ground rod are the most important, as far as reducing the electrode resistance is concerned. Soil resistivity can be reduced anywhere from 20 to 90% depending on the soil texture and treatment.

There are a variety of chemicals suitable, the most commonly used chemicals are common rock salt and magnesium sulfate. Magnesium sulfate is the least corrosive, rock salt is cheaper and does the job but should be applied in a **trench around the electrode**.