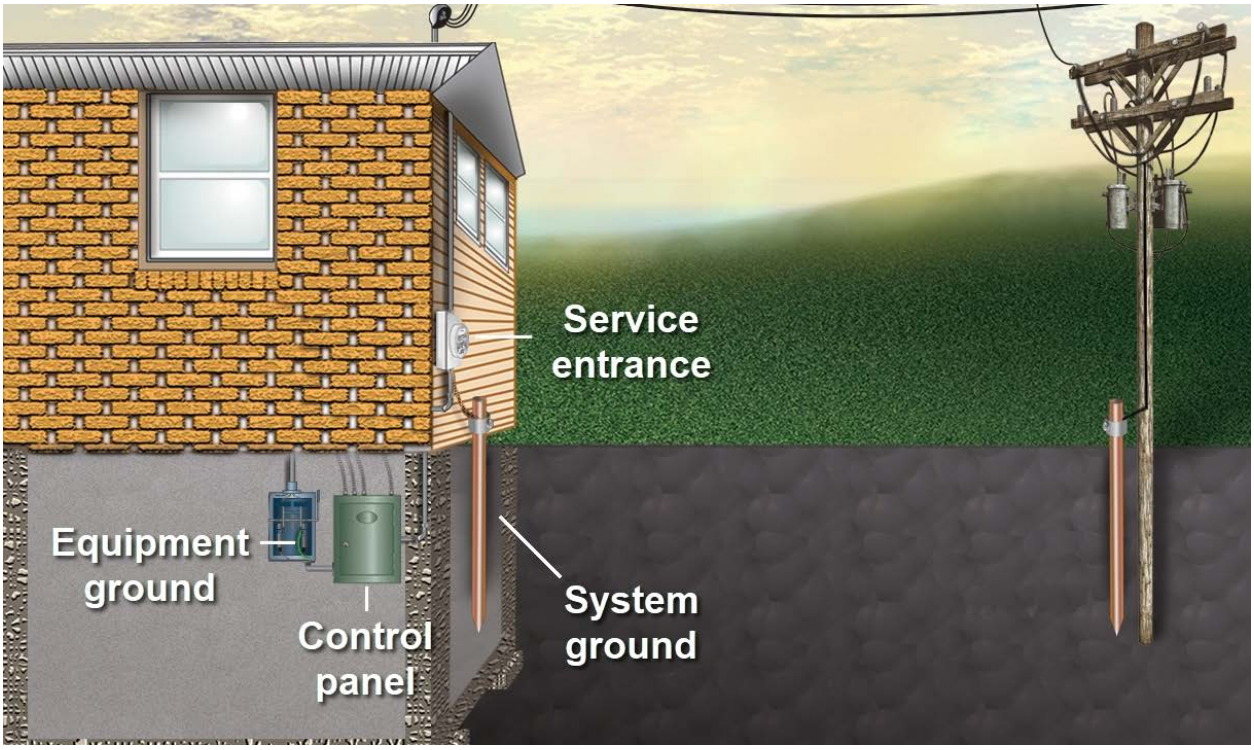
Grounding Systems Primer

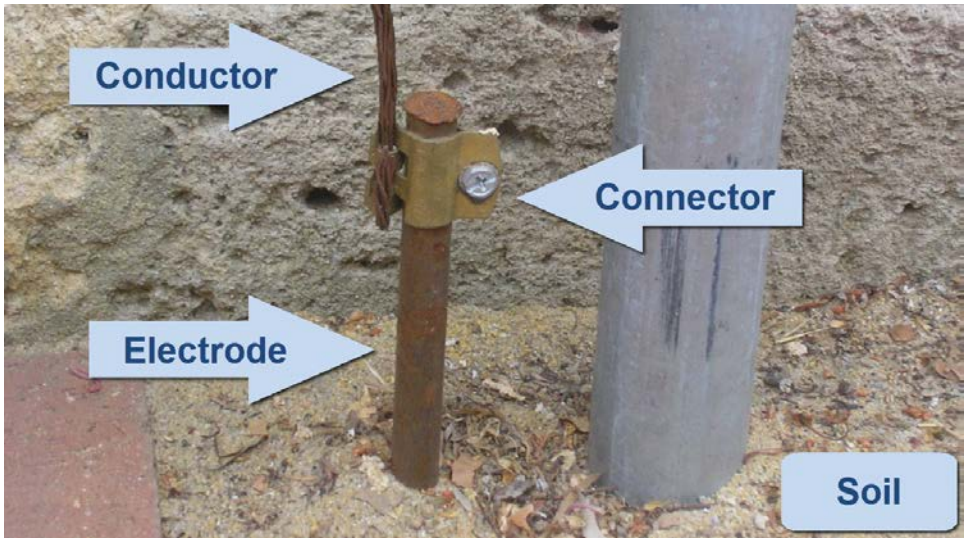
In an electrical system, effective grounding ensures a safe working environment as well as proper equipment performance. A “ground” is a conducting connection by which an electrical circuit or equipment is connected to earth. This connection is used to establish and maintain as closely as possible the potential of the earth on the circuit or equipment connected to it. This connection to the earth provides a low impedance path for electrical currents to travel under fault conditions.

For example, most people know that the third pin on the line cord of an electric appliance is the ground connection. When a piece of electrical equipment is plugged into a wall receptacle, the ground terminal connects all exposed metal surfaces of the equipment to a common connection, called the “equipment ground,” in the building’s electric service panel. From this point the ground connection typically exits the building and is connected to the system ground at the building service entrance.

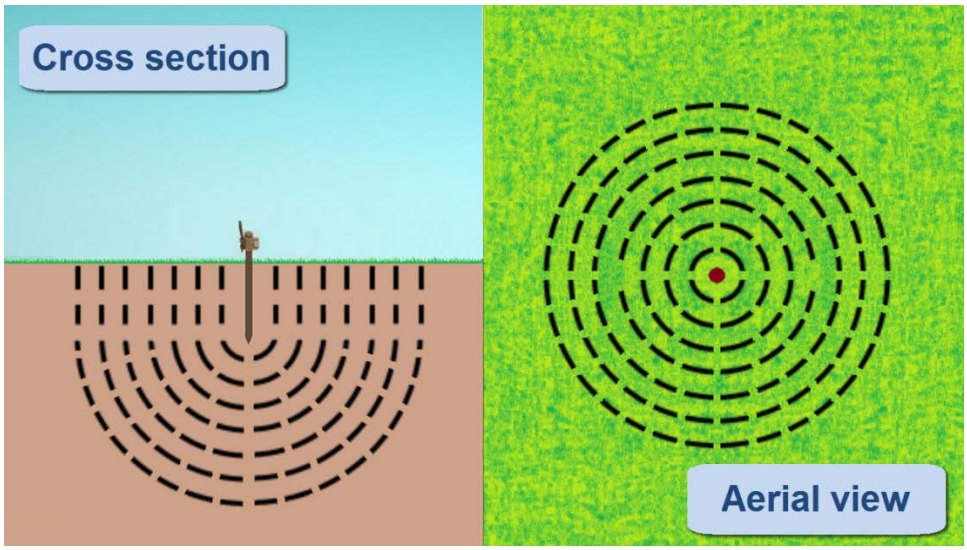


The system ground can be a simple metal rod driven into the ground as shown above, a grid consisting of multiple electrodes, or another type of grounding system.

Grounding System Components
A grounding system typically consists of a grounding conductor, a bonding connector, its grounding electrode (typically a rod or grid system), and the soil in contact with the electrode.



An electrode can be thought of as being surrounded by concentric shells of earth or soil, all the same thickness, with each successive shell having a larger cross-sectional value. Each successive shell offers less and less resistance until a point is reach that it adds negligible resistance. Current from the grounding electrode radiates in all directions in the earth through these concentric shells. The lower the soil resistivity, the lower the effective grounding electrode resistance will be as measured by a ground resistance tester.



Grounding systems can range in complexity from a single rod driven into the ground, to complex grids consisting of multiple rods connected with wire mesh, to other types of grounding systems incorporating plates, concrete, chemicals, and soil conductivity enhancers.

Rods

The most common electrical grounding system consists of a single rod. These are familiar sights for providing grounding for homes, utility poles, and similar structures.

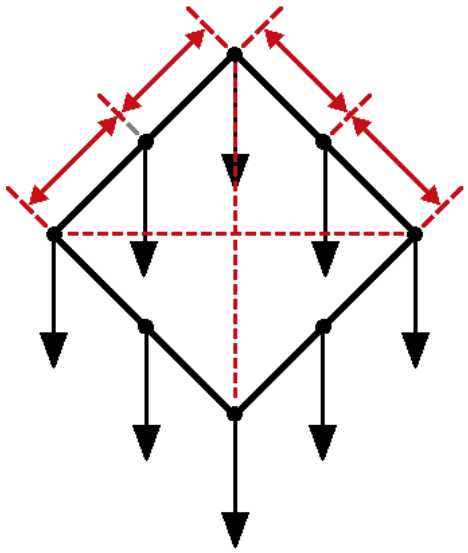
The rod is typically made of copper, stainless steel, or other highly conductive metal, often in combination. The composition, size, and length of the rod (along with the characteristics of the local soil) determine the efficacy of the grounding system.

Note that increasing the diameter of the grounding electrode does not significantly reduce its resistance. For instance, doubling the diameter reduces the resistance by less than 10%.

However, driving the ground rod deeper into the earth does substantially reduce resistance. As a general rule, doubling the depth to which the rod is driven into the ground reduces its resistance by up to 40%. However, this has its practical limits.

Grids

Grounding systems can be grids consisting of multiple rods connected together. Grids are commonly designed for substations and similar facilities to provide the lowest possible earth resistance values, as well as to create an equipotential zone throughout the entire station. The fence surrounding the substation is usually included in this zone for safety reasons.



Multiple rod grids are typically constructed with ground rods exothermically welded to copper mesh, creating a large area of zero potential earth when installed properly.

Other Grounding Options
In addition to single rods and grid systems, other grounding design options are available. These include:

- ***Grounding plates***. These are typically thin copper plates buried in direct contact with the earth. Grounding plates are often placed under poles or similar structures.

- There are also concrete-encased systems, often called "***ufers***" within the industry. These can be one or more copper rods, rebar, wire, or mesh encased in concrete, often incorporated as part of the building's foundation.

- Also used are ***chemical rods*** consisting of a hollow electrode filled with electrolytic salts (see below). This option can provide an efficient ground system in locations where poor soil conditions are present and spacing for electrodes is limited.

- Chemical rods are often used in conjunction with ***soil enhancement materials*** that improve grounding effectiveness. These materials can also be used in other grounding systems located in soils with poor conductivity.

For more information on grounding system design and testing, consult the AEMC workbook "Understanding Ground Resistance Testing" (https://www.aemc.com/userfiles/files/resources/workbooks/950-WKBK-GROUND-WEB.pdf).