

June 26, 2023 LeeCARES Net Training: Faraday Cages

Presented by Jason Korb, KI5ABB

A Faraday cage is an enclosed space with an outer layer that conducts electricity. The physical shape of the Faraday cage does not matter, it can be spherical, cylindrical, or a box. Either the cage itself can be made of a conductive material, or the cage can be built of a non-conductive material such as wood and then covered in a conductive material. The conductive material can be as simple as several layers of aluminum foil, which makes constructing your own Faraday cage a fairly simple and inexpensive affair.

What are Faraday Cages Used For?

Faraday cages are designed to guard whatever is inside of it from excessive levels of static and non-static electricity. This can be accomplished either by reflecting incoming electric fields, absorbing incoming fields, or creating opposing electrical fields. The Faraday cage can help to protect whatever electrical equipment is contained within it from an electromagnetic pulse (EMP). It's good practice to keep your emergency electronics such as radios and GPS devices stored in a Faraday cage, so they are not incapacitated in the event of an EMP.

How Does a Faraday Cage Work?

Incoming fields are cancelled when the free electrons in the conductive material on the Faraday cage instantaneously realign themselves and block the incident electric field. For this to work, the cage must be made from a conductive material; otherwise, the free electrons are not sufficiently mobile to realign themselves. The layer of conductive material can itself be quite thin. This is thanks to the "skin effect," which is a term that describes the inclination of electrical currents to move mainly on the outer layer of a conductor. Provided that the conductive layer is more than the skin depth of the material, the electrical shielding of the Faraday cage will be outstanding because there will be very high levels of absorption loss. The skin depth is a function of the material the conductor is made of and the frequency of the incoming wave. Typically, wrapping your Faraday cage in several layers of heavy-duty aluminum foil will give you the needed skin depth to protect your electronics from high frequency radiated fields like the kind generated by an EMP.

Building a Faraday Cage

The material you use for your Faraday cage does not have much influence on how effective the cage will be at protecting your electronics from high-frequency fields. Virtually any metal has the necessary conductivity to allow free electrons to realign and cancel out incoming electric fields. Certain metals are more conductive than others, which gives them a reduced skin depth – for example, at 200 MHz, silver has a skin depth of less than five microns, as compared to aluminum, which has a skin depth of 24 microns at the same frequency. But on a macro scale, that difference is negligible, which is why you can use heavy-duty aluminum foil, instead of far more expensive materials.

Your Faraday cage can have small holes in it, provided they are not too large with respect to the wavelength of the incoming electromagnetic wave. This is why you can also use fine aluminum mesh to build a larger Faraday cage. For example, a 1 GHz wave has a wavelength of 0.3 meters in space. Generally, with these kinds of mesh cages, the cage door is typically the part that causes the most leakage, but this can be fixed by taping the seams with conductive tape.

You can also use existing metal containers as Faraday cages, including metal ammunition boxes, metal garbage bins, anti-static bags, and even unused microwave ovens. Each of these has its own level of effectiveness: the main concern is that gaps and seams are minimized to reduce leakage. You do not have to ground your Faraday cage to protect the electronics contained within, although doing so will help to keep the cage from becoming charged and possibly re-radiating charge, which could be dangerous if you touch it.

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Large Faraday Cages

If you want to build a larger “shield room,” as engineers refer to rooms that are essentially large Faraday cages for storing electronics, you can do so by covering the inside of a small room or closet with several layers of heavy-duty aluminum foil. Overlap all the seams and tape them with regular cellophane tape. Cover all outlets, light switches, and other conductive breaches with aluminum foil, and do not plug anything into any outlets. Once the floor is covered in foil, place a piece of plywood over it so you do not damage it by walking on it. Such a room can store all your emergency electronics and protect them from incoming high frequency radiated fields.

Now this is just a brief overview of a Faraday cage. Feel free to get lost in the rabbit hole on the net for much more in-depth information.