

Build Your Own Faraday Cage

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June 7, 2014 By Contributor by Arthur Bradley

Introduction to Faraday Cages

There is a great deal of confusion about **Faraday cages**. Not only about how to build them, but also what they actually protect against. In this article, Dr. Arthur Bradley, author of **Disaster Preparedness for EMP Attacks and Solar Storms**, answers a few basic questions and perhaps debunks a few myths.

What is a Faraday Cage?

A *Faraday cage* (a.k.a. Faraday shield) is a sealed enclosure that has an electrically conductive outer layer. It can be in the shape of a box, cylinder, sphere, or any other closed shape. The enclosure itself can be conductive, or it can be made of a non-conductive material (such as cardboard or wood) and then wrapped in a conductive material (such as aluminum foil).

What does it do?

A Faraday cage works by three mechanisms: (1) the conductive layer reflects incoming fields, (2) the conductor absorbs incoming energy, and (3) the cage acts to create opposing fields. All of these work to safeguard the contents from excessive field levels. A Faraday cage is particularly useful for protecting against an electromagnetic pulse that may be the result of a high-altitude nuclear detonation in the atmosphere (a.k.a. EMP attacks). Despite rumors to the contrary, a Faraday cage is not necessary to protect against solar coronal mass ejections because the frequency content of such disturbances is at much lower frequencies - they don't couple energy efficiently into small-scale electronics, except through conducted paths (e.g., wires coming into the system). A better precaution against solar events is to unplug electronics and use quality surge suppressors.

How does field cancelation work?

Field cancelation occurs when the free carriers in the conductive material rapidly realign to oppose the incident electric field. If the cage is made from something non-conductive, the free carriers are not mobile enough to realign and cancel the incident field.

How thick should the conducting layer be?

The conductive layer can be very thin because of something known as the skin effect. That term describes the tendency of current to flow primarily on the skin of a conductor. As long as the conducting layer is greater than the skin depth, it will provide excellent shielding because the absorption loss will be large. The skin depth is a function of the frequency of the wave and the conductor material. As an example, consider that for a frequency of 200 MHz, the skin depth of aluminum is only about 21 microns. EMP pulses can have frequency content that ranges up to 1,000 MHz. Therefore, wrapping a box in a couple of layers of heavy duty aluminum foil (typically about 24 microns thick) provides the necessary conductor thickness to protect against high-frequency radiated fields.

Does it matter what type of conductor is used?

Not much. The conductivity of nearly any metal is good enough to allow the carriers to easily realign to cancel external fields. For example, if silver (the best conductor) is used in place of aluminum, the skin depth at 200 MHz is reduced to about 4.5 microns. Of course, the high cost of silver would prevent using it for such a purpose.

Can a Faraday cage have holes?

Yes, as long as the holes are small with respect to the wavelength of the incident electromagnetic wave. For example, a 1 GHz wave has a wavelength of 0.3 meters in free space. As long as the holes are significantly smaller than that dimension (i.e., a few millimeters), they won't let in much of the incident wave. This is why fine conductive mesh can be used when constructing a Faraday cage. In practice, the cage's lid or door usually causes the most leakage. Taping the seam with conductive tape helps to reduce this leakage.

Can you use existing conductive enclosures?

Yes, there are many conductive enclosures that can be used, including ammo cans, metal garbage cans, anti-static bags, and even old microwave ovens. Each has its own level of effectiveness as covered in my book, *Disaster Preparedness for EMP Attacks and Solar Storms*. The key criterion is that the gaps and seams remain very small.

Must the cage be grounded?

There is a great deal of confusion regarding grounding of a Faraday cage. Grounding of the cage (i.e., connecting it to some Earth-referenced source of charge) has little effect on the field levels seen inside the box. Grounding primarily helps to keep the cage from becoming charged and perhaps re-radiating. The bottom line is that an ungrounded cage protects the contents from harmful electromagnetic fields as well as a grounded one.

Anti-static Bags

Anti-static bags are readily available to protect electronic components against electrostatic discharge. They can be purchased in many different sizes, including some large enough to hold radio equipment. While they do offer shielding from EMP, not all products are created equal. Testing confirmed that products certified to MIL-PRF-8170 and/or MIL-PRF-131 offer the greatest protection from an EMP. The results from testing three different types of bags are provided in *Disaster Preparedness for EMP Attacks and Solar Storms*. When selecting an ESD bag, consider not only the shielding effectiveness but also the physical ruggedness of the bag. A tear or large hole can compromise the bag by allowing EMP energy to enter.

Larger Faraday Cages

Storing a larger set of electronics might require an entire room. Engineers who work in electromagnetics often use "shield rooms" to conduct experiments because they do an excellent job of filtering out interfering signals, providing in excess of 100 dB of shielding. A poor-man's shield room can be made by lining a small closet with heavy-duty aluminum foil, covering all four walls, the floor, the ceiling, and the inside of the door.

Overlap and tape the seams using either conductive or regular cellophane tape. There can be no conductive penetrations into the room, or it will seriously degrade the shielding. Cover all electrical outlets, light switches, etc. with aluminum foil. Do not plug anything into the electrical outlets. Also, lay a piece of plywood or cardboard on the floor so that it can be walked on without damaging the aluminum foil. Rooms built in this way have been shown to offer more than 50 dB of shielding up to several hundred MHz.