HEMP Protection theory:

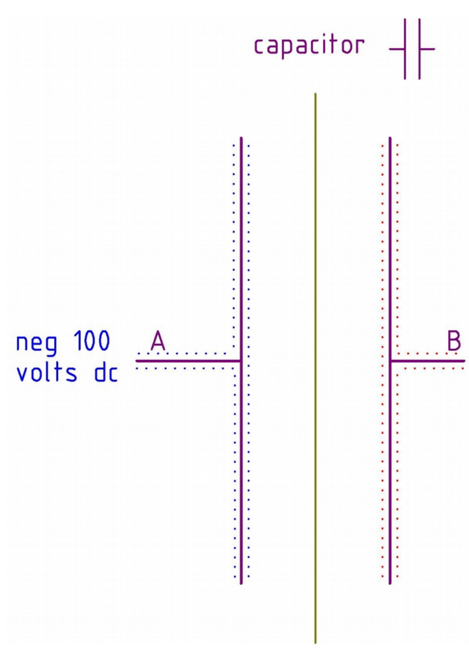
This is a simple illustrated explanation of why and how an HEMP shield works. HEMP is an acronym for: High altitude EMP from a nuclear blast. The altitude has to be above the atmosphere or at least most of it. The explosion of a nuclear device that far above the ground …
Will not:
Have a blast wave that knocks buildings down
Cause structures, people, animals or plants to burst into flames
Cause radiation burns or sickness of any kind.

It Will:
Have a primary electrical pulse (E1) that will functionally destroy any unprotected electronics whether they are plugged in or not. The E1 pulse is not an electromagnetic wave. It is an electrical pulse built by the gamma particles knocking electrons from air molecules.
Have a secondary electrical pulse (E2) that will damage transformers of moderate size.
Have a third pulse (E3) that mimics a solar EMP which destroys long lines and large transformers and generators but only within the area effected by the other two.

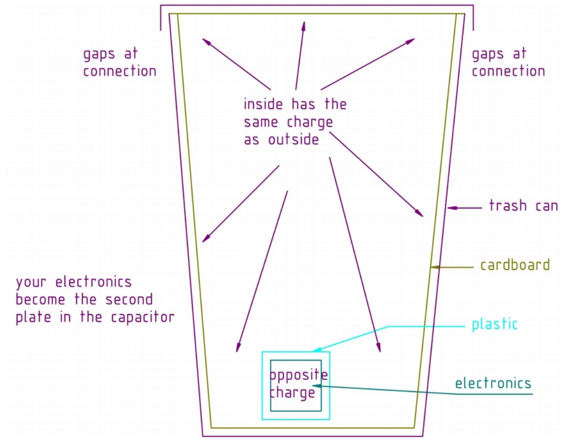
Unlike a Solar EMP the HEMP only affects the area in a line of sight from the bomb to the apparent horizon. The E3 pulse is the only one that is affected by the yield of the bomb. The more yield the more the geomagnetic field is deflected. That makes the E3 electromagnetic pulse worse.

Let's begin with a little electrical information.
When you connect an electric voltage to a metal object the entire object receives the same voltage potential. We can all understand that. Let's consider the air as a conductor. Lightning flows through the air to get to the opposite polarity. It can come from the clouds to the ground or go from the ground to the clouds. It just depends on the polarity of the clouds.
That is important because an HEMP uses the air to make the E1 electric pulse. The Gamma rays from the bomb (the part of them that don't hit other fissionable material) travel out from the bomb at nearly the speed of light. As these Gamma particles travel through the air they knock electrons away from the air molecules. That ionizes the atmosphere. (makes it charged positive) and the electrons that are "free" become a negative charge. The voltage that results is very high, at least 50,000 volts per meter, and it happens very fast (rise time). The rise time is about ½ of a millionth of a second. The duration of that pulse is only 1 millionth of a second or a nanosecond.

If we are going to protect our electronics from the E1 pulse we have to understand how to slow down its travel.
At the right is a schematic drawing of a capacitor. It is two metal plates separated by an insulator, usually plastic. If you apply a voltage to one side it becomes charged relative to the other side. In this drawing I have put a bunch of electrons on the left side so it built a charge of -100 volts. In a capacitor the voltage applied to one side can be easily discharged to the other side but takes time to fully charge either plate. Side "A" has a lot of electrons crowded over the entire surface. Side "B" has a bunch of holes for the electrons to fit into but they are separated by the insulator. You have to connect "A" to "B" to get the electrons to move. (or wait for them to leak through the insulator or out to the air.
Remember that the two sides develop opposite charges over a period of time.



Right, now let's look at one of the mythical defenses against the E1 pulse of an HEMP.
At the right you see a sectional drawing of a trash can.
This trash can has been lined with cardboard as an insulator.
At the bottom of the trash can we have a plastic bag with some electronics in it sitting on the insulation.

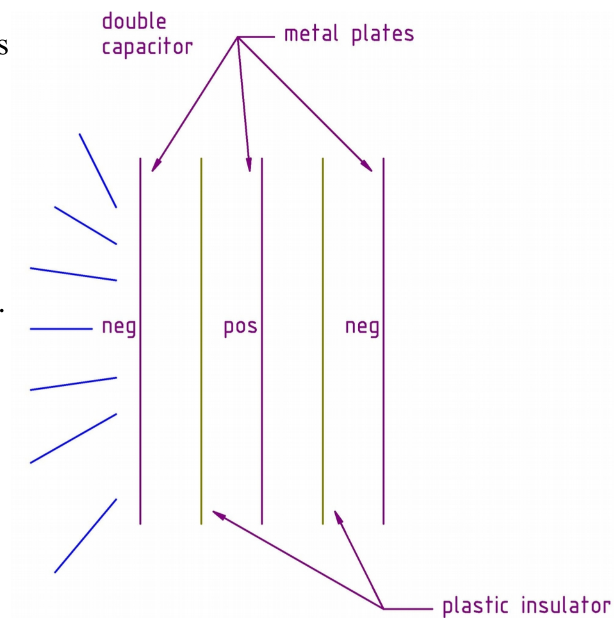


We have 50,000 or more volts around the outside of this trash can and we are trying to insulate the inside with cardboard. Cardboard is a poor insulator and the voltage leaks right past it. On top of that the cover is not a tight fit. It isn't even water tight so the E1 pulse goes through the gaps.

Remember the capacitor? Two plates separated by an insulator.
The trash can is the first plate and the only effective insulator is the plastic bag. On the inside of that plastic bag is our electronics devices that we want to protect. They have just become the second plate of the capacitor. Is that plastic bag a good enough insulator to protect the electronics from 50,000 volts? The answer is no. Our electronics have just been hit with a voltage of 50,000 with a rise time so short that every diode, transistor and IC chip has had the junctions burned away. Even with three layers of steel the pulse rise is so fast and the steel is so resistive that the pulse would penetrate the capacitor before the current could dissipate over it.
This one is a fail on three counts.
1. there are gaps that the E1 pulse can get through.
2. there is little to slow the path of the voltage.
3. there isn't enough capacitive reactance to prevent high voltages from leaking into the electronics.

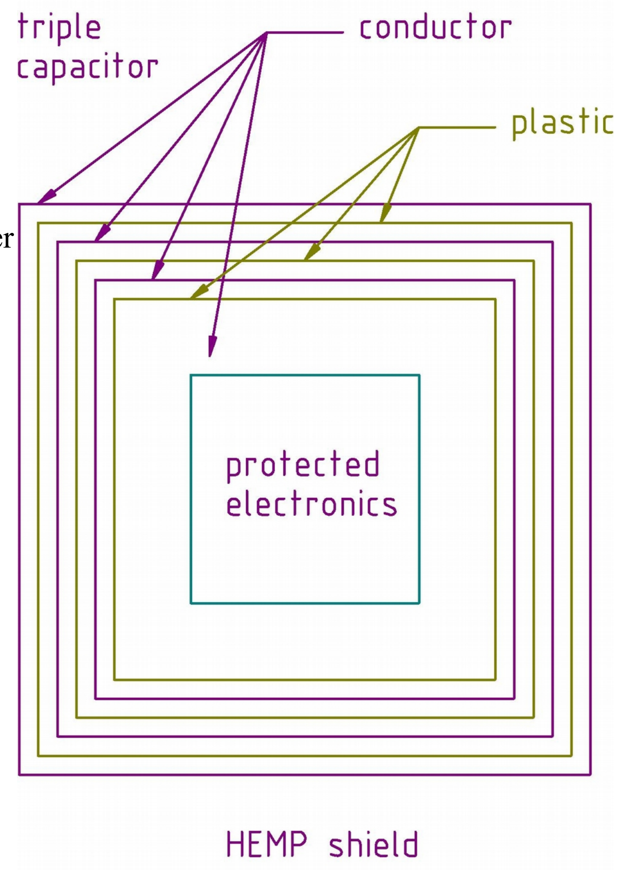
Aluminum is 4 times as conductive as steel but even if we replaced the steel trash can with an aluminum one there is only a single layer of capacitance.

If we add another layer of protection we can slow the process down better. On the right is a double capacitor. It has three plates separated by two insulators. The charge at the first plate takes time to charge the second plate and then it takes more time to charge the third plate. How much time depends on the volume of the plates, the resistance of the insulators, and the time the voltage is applied to the plates. Each plate is charged in turn and it is charged with the opposite polarity. The key here is that it takes time to charge each plate.



Let's take this idea one step further and see how it is used to make an E1 shield.

In the two dimensional drawing at the right you can see that we have constructed a four layer capacitor to protect our electronics. The first three conductors are made of heavy duty aluminum foil (heavy duty like for covering the turkey) to add to the volume of each layer. The insulation is at least 10 mil plastic for good isolation of high voltage. The protected electronics, our fourth plate, are inside that third layer of plastic.



This is what I consider the minimum protection and **the more layers you add the more protection you have**.

The E1 pulse lasts for 1 nanosecond and the capacitive reactance of this three layers of protection will not allow the conductors to fully charge in that time. The protected electronics will never see more than a moderate potential and it will likely not injure the equipment inside.

From the inside out we have the electronics, in a heavy zip-lock freezer bag, wrapped in heavy duty aluminum foil, placed in another heavy zip-lock freezer bag, with the heavy duty foil wrapped around it, and that is all placed in heavy plastic, taped closed, and wrapped in another layer of foil.

The way that the edges of the foil are sealed is important. The foil is laid flat and the package is placed so you have about two inches on each side and the two ends come together at the top with about two to three inches to spare. The bottom edge is just the folded edge of the foil. The sides are sealed by folding one inch of both layers over and then folding that one inch seam in half again. Be sure to press the seam flat to make a good seal. Then the top is folded to close the opening and the folded part is folded over again. The seam is then pressed flat to lock the seal.