LunchNLab Common Mode AC Line Choke

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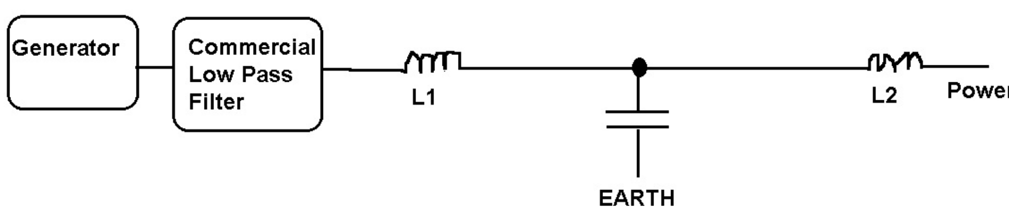
PURPOSE	To attenuate "common mode" (appearing identically on hot and neutral wires) radio frequency interference coming from fast-switching transistors in AC inverters, inverter generators, and solar power charge controllers. Typically will need to be utilized in addition to a differential mode filter. For modest currents (up to 5-10 Amps) these are widely available. This common mode filter is made with 16gauge wire and should be good for 12-13 amps depending on ambient temperature.
HOW IT WORKS	The extension cord attached to an inverter generator looks like a nice end-fed antenna to the fast-switching broadband-hash-generating transistors inside. The generator itself is the "counterpoise" and its capacitance to the earth below. The basic features of any analog filter (made with simple electronic devices, not one constructed in software) are: 1) a reactance in series (L1 in the diagram below) that tends to oppose the flow of the undesired signal, and 2) a reactance as a shunt ("parallel") to ground at the far end (the unnamed capacitor in the schematic below) hat tends to short out the undesired signal that gets through the series reactance.  In this case we are building a LOW PASS FILTER -- we wish to pass the 60Hz desired AC power, and we wish to filter out any higher frequencies, such as the 80 meter or 40 meter ham band. In order to do that, we put an inductor in series, and try to arrange for a capacitor (to ground) on the far end, away from the generator, to short out the remaining signal. The generator sees that its nice end-fed antenna (the extension cord) now has a much higher input impedance, and is unable to force as much interfering signal into it. The "capacitance" on the load (radio) end of the series inductor could be some real capacitors connected to ground, but likely will be just the inherent capacitance of the wires of the extension cord to the ground below them. It would be advantageous to

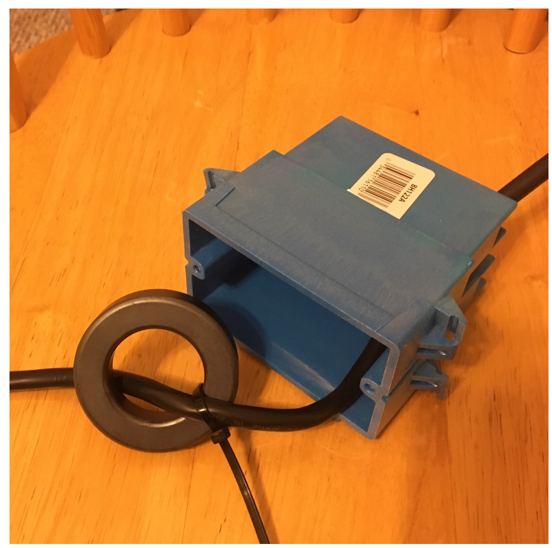
	a) put the generator as far away from the radio as possible b) lay the extension cord right on the ground in the intervening distance c) potentially add additional series chokes at points along the extension cord (creating a "multi-section" filter).
Toroid Inductors	Its useful to learn how to calculate the inductance created by putting turns around a toroid. Especially the fact that the inductance goes up by the SQUARE of the number of turns! L (inductance in microhenries) = $(A_L * N^{2)} / 1000$ For the FT-240-43 ferrite that we are using (FT = it is a ferrite rather than an iron powder, toroid) (240 = size of toroid) (43 = toroid ferrite material) A_L = 1075 microhenries per turn-squared and if you can get NINE turns of the extension cord wrapped, L = (1075 * 81)/1000 = 87 microHenries (which in radio terms is a lot!)
How much reactance at 80 meters, 40 meters?	Formula for inductive reactance (in ohms of inductive reactance) X = 2 * pi * frequency * inductance, where frequency is in Hz and inductance is in Henries 80 meters = 3.5 MHz $X = 2 * 3.14159 * 3.5 \times 10^{6} * 87 \times 10^{-6}$ X(ohms) = 1912 ohms inductive reactance at 3.5 MHz. At 7 MHz it will be twice this, or almost 4000 ohms inductive reactance. That seems like a LOT when you think of a 50 ohm system....but the impedance of the extension cord viewed as an "end-fed antenna" can be thousands of ohms, so putting 4,000 inductive obstacle ohms in series *helps*, but not enormously. But if you already have one filter in place --- this can add quite a few more dB of filtering. Every bit helps!!! If you have multiple volunteers on site, you can pool your filters together and space them out on the line...
How This Fits Into Our Emergency Preparedness	With each project that our group does we are • increasing the ASSETS that we have available to make communications work in difficult situations *and* • increasing the SKILL LEVELS of our volunteers

CONSTRUCTION STEPS

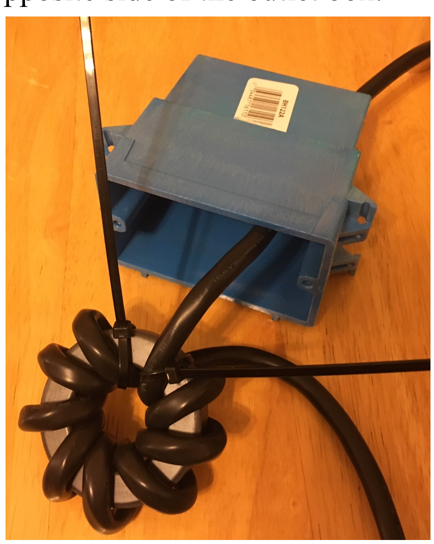
1. Initial components
    - 10 foot three wire, 16-gauge extension cord (e.g. Walmart)
    - FT-240-43 toroid (suggest https://kitsandparts.com/store2.php)
    - Deep (approx 22 cu inch) single gang non-conductive electrical outlet box (98 cents @ Home Depot)
    - Blank cover for outlet box.

Open up one opening at one end of the box for entry, and one opening at the opposite end of the box for exit.

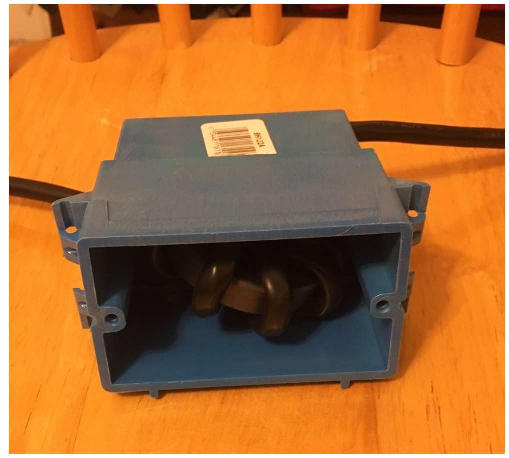
2. You can't get either the plug or the socket of the extension cord through the small holes in the outlet box, so we're going to have to CUT the extension cord and later splice it back together. Cut the extension cord at approximately 6 feet from the male plug end, and feed 5 feet of the male plug end wire from the outside, into the inside of the outlet box, leaving one foot of extension cord and the male plug on the outside.



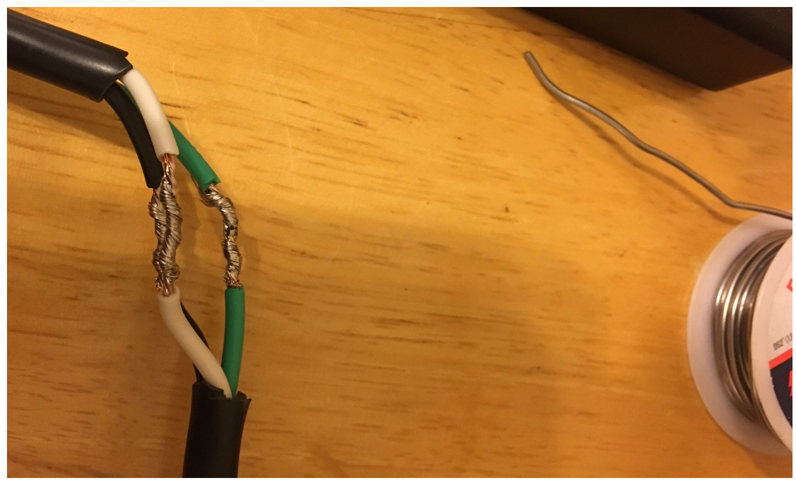
3 Starting about 6 inches down the inside cord, make your first pass through the toroid and secure it with a zip tie (makes it a lot easier to proceed.) Then finish with 9 turns around the core (remember: each pass through the center equals a turn) and secure the final turn with another zip tie--and feed the remaining extension cord out through the opposite side of the outlet box.



4. Stuff the wound toroid into the plastic outlet box and secure with the gray cover.



5. Carefully splice back in the female socket end, white-to-white wire, green-to-green wire, black-to-black wire, solder, making sure that no sharp little wires are sticking out.   If you use old-fashioned 60/40 solder you'll get a shiny solder joint; newer solders maybe not so shiny..



6. Wrap each wire individually with electrical tape in a close spiral, and then and go back over the opposite direction so you have two spiral layers of electrical tape on each connection, **no sharp wires sticking through the electrical tape.**

7. If you think ahead you can preposition some heatshrink to cover the entire thing, or just wrap with two or more layers of spiral electrical tape.

8. Completed common-mode AC line choke:

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