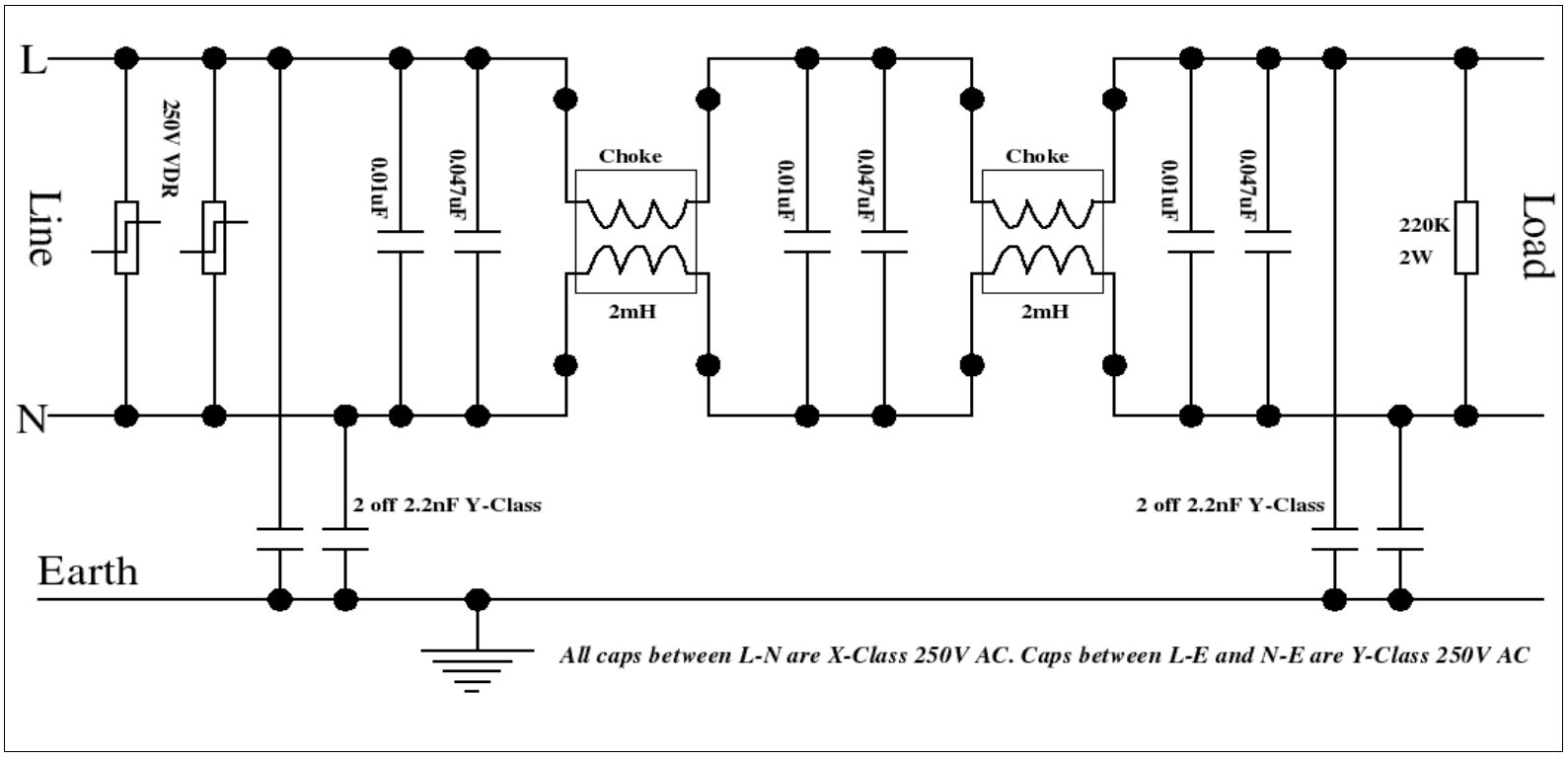
The Feed Through Mains Filter (Full DIY)

This filter is a complete DIY solution where you make the circuit yourself, either on a PCB, vero-board or preferably tag strip from the basic components listed. The easy DIY mains filter project in my other article is aimed at those who want an easier build and quicker solution. This project is aimed at those who enjoy building from scratch and want to tweak component types and values maybe at a later date.



The circuit above shows a dual stage mains filter. It is a feed through type, in that un-filtered mains is connected to the input (line) and the equipment connected to the output (load).

Advise on Building the Unit

X-Class capacitors are specially designed to be connected across the mains supply and Y-Class between the supply lines and earth. Y-Class types are double insulated. The choke has its two coils wound in opposite directions. The resistor at the end in the circuit discharges the X-Class capacitors when the unit is switched off. The exact values of the X-Class capacitors in this circuit are not critical but care must be used as not to use too high a values. There are safety limits on what can be connected across the mains and even more so between the lines to earth. Also the components MUST be rated as X and Y-Class for safety.

This circuit has been built and fully tested by me and a few others in the World Audio Design forums with excellent results so you can go ahead and build this filter. It is also possible to wind the chokes yourself if you cannot find a supplier of ready made chokes or want to keep costs to bare minimum. Each winding on the choke should be in opposite directions to each other. That is the neutral winding runs the opposite way to the live winding. The live winding is made on one side of the choke and the neutral on the other with a gap between. The chokes should be around 1 to 2mH. A medium to large ferrite ring can be used as the choke former and these are commonly available from Maplin or RS or out of old switch-mode power supplies. Use enamelled copper wire, which is also easily available, for the winding at the current rating required. An inductance capable multi meter is very useful to measure the value of the choke if making your own.

However RS and Farnell sell a ready made common mode choke (RS part number 188-9040, Farnell part number 522-896) rated at 10A 2mH which is a very well made potted choke and I recommend this rather than make your own unless on a very tight budget. It is then a matter of mounting mains sockets for an output to suit the number of items you want to feed into a box and feed normal 'dirty' mains in. I would suggest a case with some screening if possible but not essential. If the case is metal then make sure it is earthed.

You can use dual tag strip to assemble the circuit which is what I did and is much better than vero-board. One side of tags for live and the other side for neutral. Reserve some central tags for the earth connections. The varistors need to be rated at 250V AC RMS or slightly higher and ideal is to use more than one varistor in parallel at the input (2 or more).

Remember that most HiFi does not pull as much from the mains as people imagine so a choke that can only handle a few amps is sometimes enough. My 300B mono block's pull 50W each and my CD Player 40W. A typical pre-amp will pull less than 40W so total is just under 200W. In the end you should have a filter that easily competes with the those on the commercial market at a fraction of the cost.

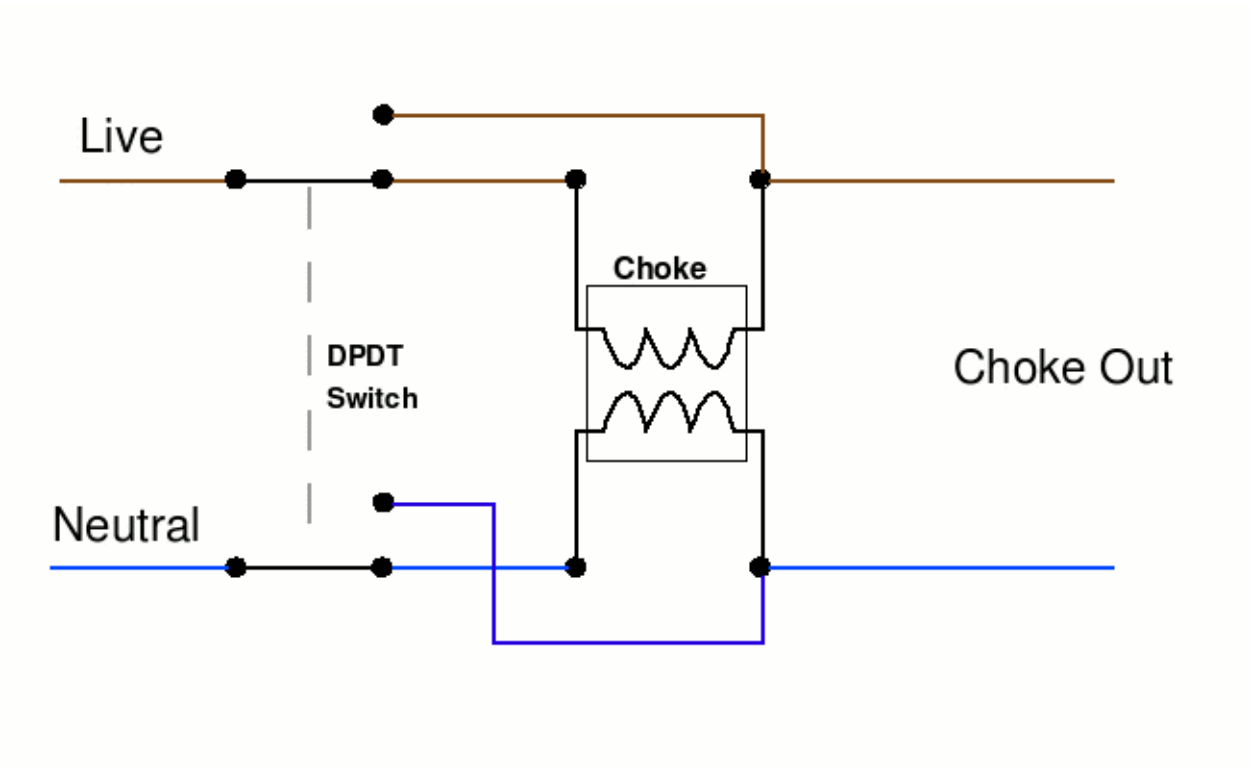
What, no Chokes

Some filters designs do not use chokes claiming that they increase the mains impedance. Well that is correct; a choke does that, which is exactly what they are designed to do, but only at high frequencies. At 50/60Hz mains frequencies a choke will appear as a piece of copper wire with no attenuation at all. The choke will only come into effect at high frequencies, i.e. where the unwanted noise is. The higher the frequency then the greater the attenuation level. The idea is that the choke blocks all RFI noise but does not alter the AC sine wave at normal (low 50/60 Hz) frequencies and presents no load. It is possible to plot a frequency trace of the DIY circuit using some circuit simulation software like PSpice. Most chokes will only start to attenuate in the Khz region so under this they have no effect and certainly none to a sine wave at 50/60Hz.

However the choke inductance size can be critical depending on what the filter will be feeding. If you are supplying a CD Player or DAC then a large value choke or multiple stages with chokes does seem to work very well, were-as using this setup with a power amplifier in some systems can 'flatten' the sound very slightly. In the case of a power amplifier a much smaller value choke and series inductance with a large current capability would be a better choice. In my own system I still prefer the sound with a choke in the filter for a more natural cleaner and smoother sound.

Choke and Filter By-Pass

Check out the choke by-pass switching idea and parallel switching idea in the other articles I have which can be fitted to this design to allow you to operate the filter with and without the series mode chokes and as a series switchable parallel design. One crude method of choke by-pass is shown below.



RS Part Numbers

238-621 Varistor 275V AC 61J (5 in pack) **** or buy from me cheaper ****

214-2263 2W Power Oxide Resistors, 220K (10 in pack)

188-9040 RFI Supp Choke, 10A (Order 2 of These for the Dual Stage)

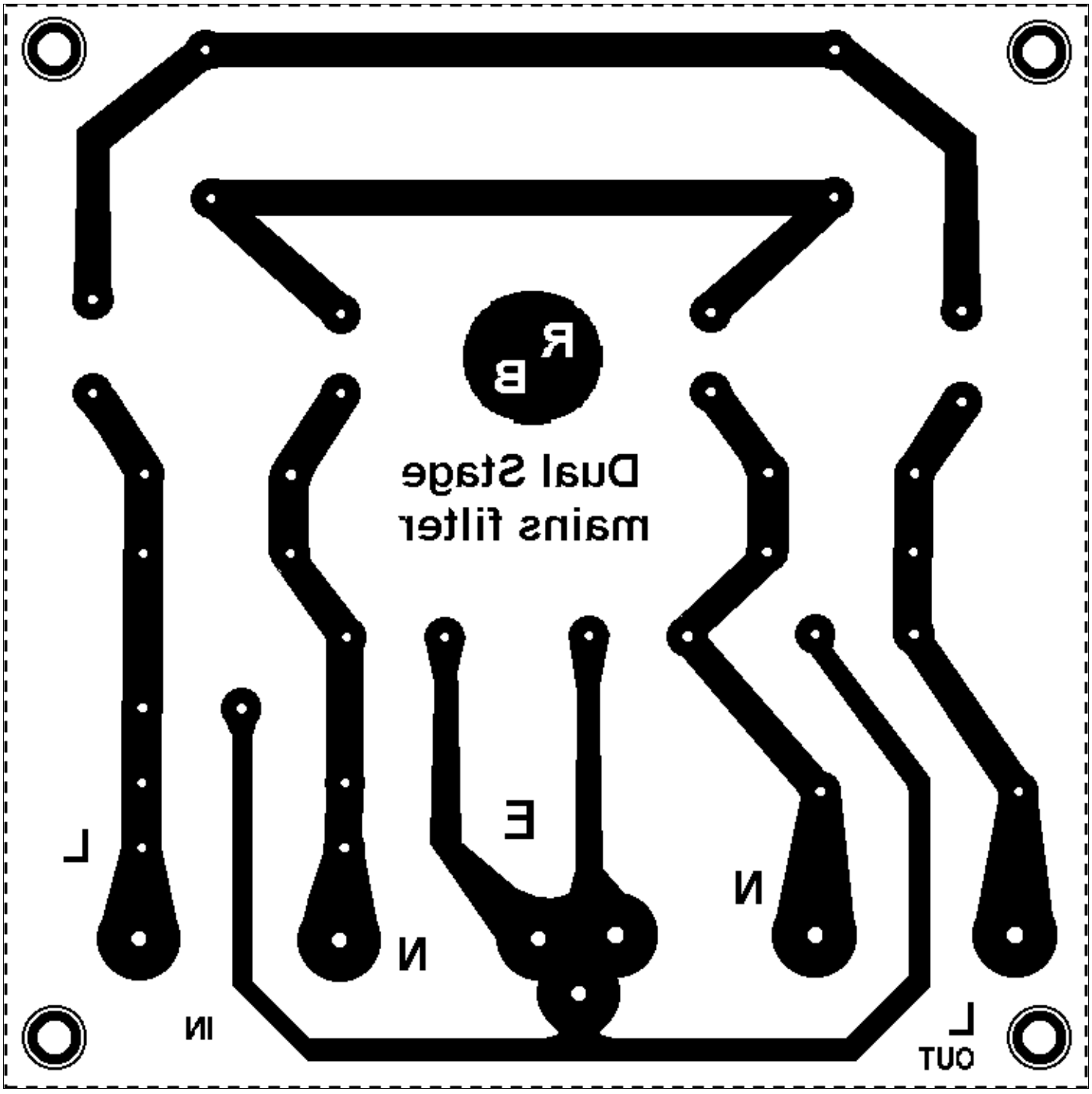
441-9521 Capacitor X1 Class 0.01uF (10 in pack)

441-9537 Capacitor X1 Class 0.047uF (10 in pack)

441-9830 Capacitor Y Class 0.0022uF (10 in pack) OR 0.0033uF

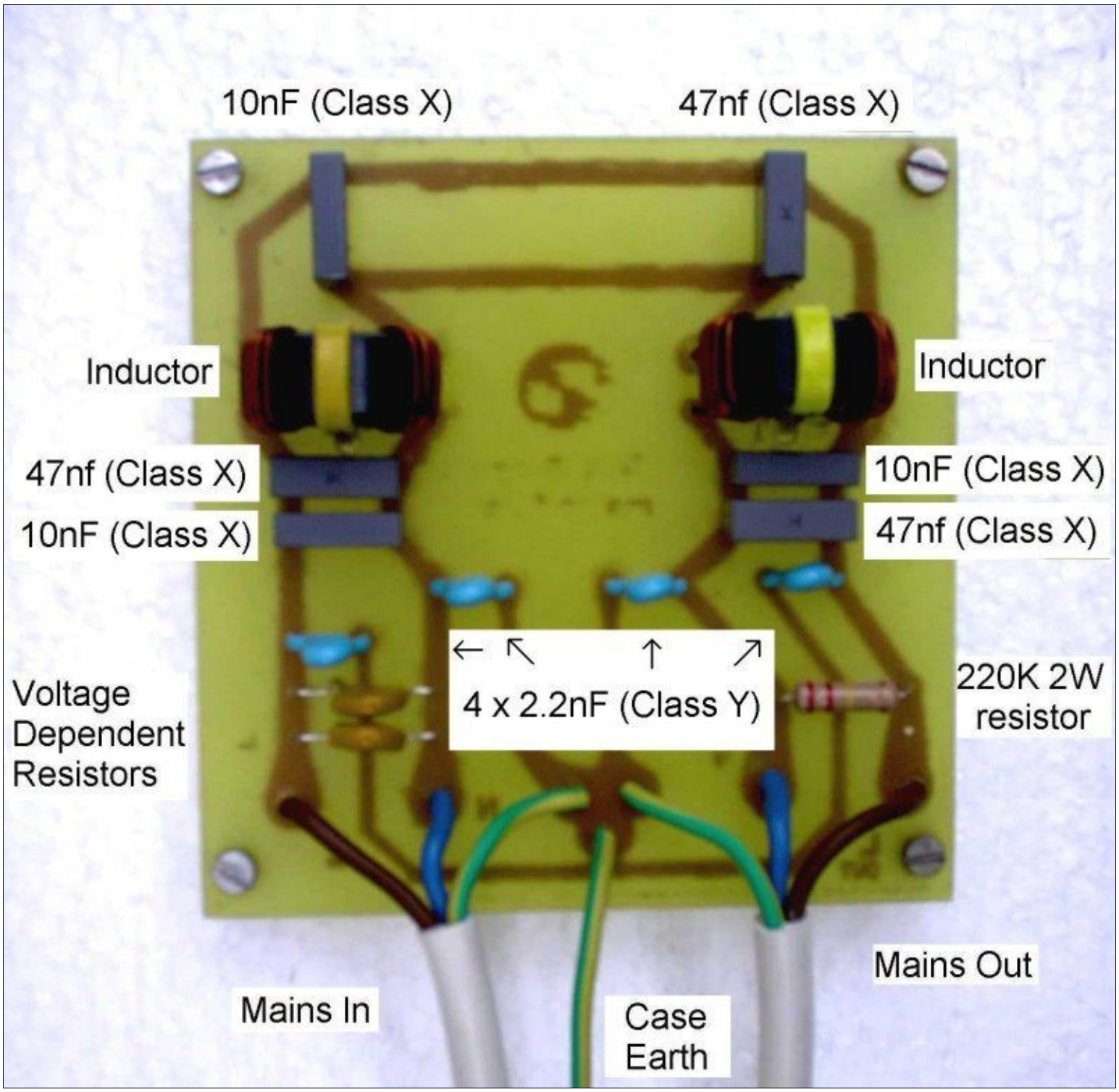
DIY Audio HiFi Mains Filter - PCB Layout

First I must thank Will B and Chris R for sending me this PCB layout they designed for this project and the completed pictures. The circuit is a dual stage mains filter using 2 chokes and is a feed through type, in that un-filtered mains is connected to the input (line) and the equipment connected to the output (load). Will has drawn out a PCB that can be used to build this project for those of you that prefer PCB builds to veroboard or tag strip. The tracks on the pcb are fairly wide but they can be thickened with solder or copper wire soldered along the tracks if it is likely to carry a high current. I think adding solder along the tracks is worth doing anyway for the little extra time involved.



This is the PCB if you was looking through the PCB from the top. If you have a printer, a laser type is ideal for this task, you can print this onto printable transparent film sheets. This film can then be used in a UV box to expose against UV sensitive PCB prior to etching. ***See notes below for scaling PCB to 1:1***

<PCB design by Will B and Chris R>



This is the top side of the PCB when populated. You can use this to aid component placement after your PCB has been etched. The chokes are home made and wound on ferrite cores. However you can still use the ready made potted chokes from RS or Farnell if you wish. Ferrite cores for this project can be salvaged from old switch-mode power supplies such as an old PC power supply for example.

Regarding the use of transparent film for UV based PCB etching, this is the film commonly used for feeding through laser printers or photo copiers which toner can adhere and fuse to. If you print 2 copies at a high toner density setting they can be over-laid on top of each other and taped together at the edges to increase the darkness of the tracks. The objective is to block UV reaching the PCB surface where you want tracks to form so the darker and denser the blacks on the film then the better. It may be possible to buy film suitable for use with inkjet printers but seeing as I have used a laser printer in the past for this technique I cannot confirm about the use of inkjets. UV sensitive PCB or Pre-Sensitised Copper-Clad Board is available from RS, Farnell and Maplin along with the developer solution and etching fluid. There is a little more prep work involved when making a PCB before the actual build but this method is ideal if you plan to make a few mains filters, either for different parts of your audio system or one for the Hi-Fi and one for the home cinema setup, TV etc.

**** Scaling the Filter PCB Image to 1:1 ****

Once you save the PCB image to your computer you need to print it at the correct scale before using it to make a real PCB. This may vary slighty between printer and the paint package you use to print it. The easiest way to get the correct scale is to print the PCB on plain A4 paper first and see if the component legs line up with the holes in the PCB without the need to bend them out or in too much to fit. If it is too big then scale the image down and re-try until you get the correct scale. In my setup I use Fedora Core Linux and a program called The Gimp for image processing and printing. I found that the image needs to be scaled down to 60% size. That is I printed the image at 60% and that was perfect. Therefore I would try 60% scale to start with. Any half decent paint program has a scale option and the ability to print out at different sizes. Will said that he used MS word to scale the image and fit a few copies on 1 sheet of A4 before printing so that is another option. Either use your existing word processor / publisher or download openoffice which is a free open source office suite and give that a try.

David