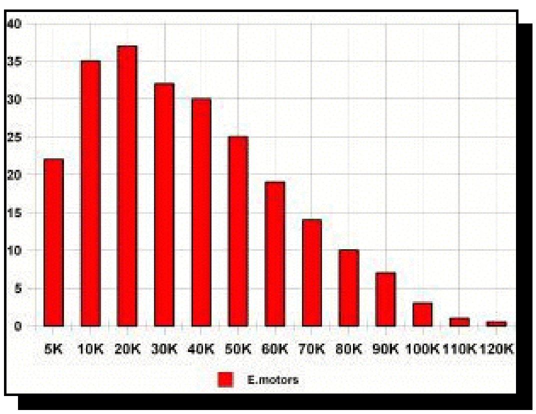
Filter ahoy!
Part 1

A Small Intro

Line filters are more often called "conditioners", which is a pompous name for what is essentially a filter. How it does its job has nothing to do with what it does, and ultimately, no matter which approach is taken, their only function is to filter out the rubbish in our power lines. Therefore, when you see something like "power conditioner", be aware that you are in fact facing a line filter, with a few options added, the most popular being a surge suppressor.

Noise and where it comes from

Ideally, our power lines should contain nothing but 50 or 60 Hz, which are needed to make our supply alternating current, AC, as opposed to direct current, or DC. But we don't live in an ideal world, and our power supply lines in fact contain so much garbage that oscilloscope pictures are often hard to believe. To appreciate this, we need to look where does all that noise come from.



Typical electric motor noise distribution

Its prime source are household appliances which use electric motors. Upon turning on, every electric motor is in a short circuit, and thus sends back a part of the energy needed to start it back to the grid – this is known as "inductive kickback". Many such motors use brushes and commutators, and every time a brush is worn, it starts to create sparks on its contact, these sparks being signals sent back into the grid. Electric motors use so many poles, typically 4 to 16 poles, and each pole has to be connected and disconnected, thus creating a signal. Say your motor revolves at just 500 rpm – using the typical number of poles, it sends back a signal to the grid ranging from (500x2) 1 kHz to (500x16) 8 kHz – and that's just the fundamental, and there are harmonics.

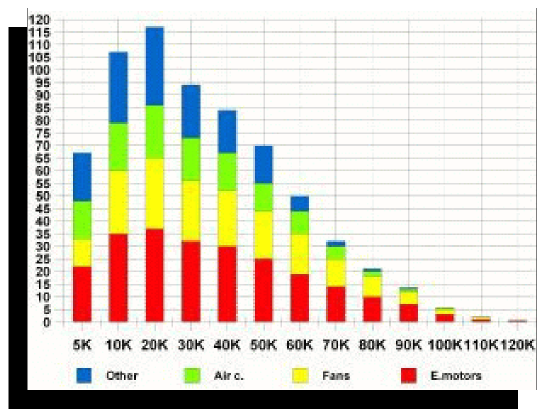
By far the worst power line contaminator are hair dryers. Their manufacturers are forever pushed into producing ever better looking, ever more powerful models, and since most of the money goes on heaters, design and advertising, electric motors used in them are typically of the worst possible kind and quality, but of course, very cheap. But they also rotate faster, typically st 1,000-3,000 rpm, and being generally 8 or 16 pole types, send back signals into the grid ranging from 8kHz to 48kHz, plus harmonics.

And if you should happen to have an appliance which still uses brushes, then you're really in trouble! They wear out fairly soon and their degraded contacts are a miracle of line noise production, and at possibly intolerably high levels too if that happens to be a powerful electric motor, such as the one used in vacuum cleaners and fridges.

Speaking of fridges, ice boxes, deep freezes and such like, but also of any other appliance using a thermostat and a start-up capacitor, you really don't want to see what the initial start-up spike looks like. Quite normal – you see, once the motor starts, that capacitor has nowhere to discharge, nowhere except the power line, that is. So it discharges, and you could easily see lights flicker, or your TV blink at that moment. I have seen a few cases, really bad ones, when that spike used to cut the PC out, simply reset it, much to the joy of their owners.

Now, think – how many electric motor powered appliances do you have in your home? I know mine – fridge, deep freeze, dishwasing machine, laundry machine, vacuum cleaner, two air conditioners, hair dryer and three PCs. Not very different with you, is it? Actual numbers may vary, but basically, most have some arrangement like the one above.

PCs are also a very bad source of pollution, for two reasons. One is their switchmode power supply, which rarely has a filter to prevent signals being sent back (I have seen them built-in no more than 3-4 times over the last 16 years), and the other are a multitude of electric motors inside (CPU fan, PSU fan or fans, hard disk drive motors (2 in each), CD ROM drives), and of course, many local oscillators, few of which (if any) are buffered.



Household noise sources shown as cumulative series. Note how noise adds up.

Finally, we come to the cables. To get power to where we want it, we routinely use cables. These cables also act as aerials, antennas, picking up anything that's in the air. Radio and TV signals, GSM signals, cordelss telephones, and such like are usually mentioned, and all that's true. However, what is usually lacking is mentioning the fact that the relative POWER of these disturbances is very low, and hence not too much of a problem – how powerful is your mobile phone? Not very, believe me. These can be a problem if our power cables are long, say 2 meters (app. 6.6 ft) or longer, simply because the longer they are, the better aerials they will be, picking up more and more stray intereference, until even small signals pile up and start being a very real problem.

But what you will rarely find said is that the relative distribution of line disturbances is in the 5-50 kHz range, simply because that's where most of the on-line sources are and because these are the sources with the greatest relative power. To us, audiophiles, that's about the worst possible news, because obviously, most such problems occur exactly where we DON'T want them. It's also bad news because it's very hard to filter that out, very hard but not impossible. Finally, line noise is typically assymetrical in nature (i.e. it does not behave as a perfect sine wave), has a random pattern, and worst of all, tends to intermodulate among sources in addition to building up (adding noise upon noise lifts the noise floor). Terrible, huh? And we talk about great sound …

A few notes on filters/conditioners

Obviously, line filters have not one, but several contradictory jobs to do. They should not touch our basic 50/60 Hz signal, but should act as brickwall filters right after that – not easy, or even possible to do. They should be as steep as possible, yet should not cause our large current devices, namely amplifiers, to drop in dynamics, which can happen with poorly designed filters/conditioners. They should filter well, yet have sufficient power handling to satisfy at least most of us; making a high quality low power filter is easy, but making a high quality, high power filter is very hard ("high power" being a very relative term, in my view anything over say 600VA is high power).

That much is obvious; now let's take a look at the less obvious aspects. A filter/conditioner should be transparent, meaning you should plug it in and never bother to look at it again, while it does its job. This means it should be designed to do its job for a long time with no trouble. If it is a typical passive filter, it will have something, whatever, connected to the ground plane – and that's bad. You see, ground planes are just another unpredecitable variable – are they really on ground potential or not? Most are not. And when something comes along, where does the filter send it? To the ground of course, but due to a large power nature of whatever has just been sent to the ground, its potential changes and it is no longer an ideal ground; this effect is known in broad terms as "ground modulation".

Basically, there are three types of filters used for power lines today. One is of the kind Nels recently reviewed, which uses large power transformers to divide the incoming voltage into two halves, phase inverts one half, sums them up again and looses most of the junk in the process due to cancellation between "plus" and "minus" phases. To be sure, this works, but has many drawbacks as an approach – it's bulky and very expensive to make, it assumes high precision of matching for effects, it assumes top quality transformers which will not saturate easily, it requires heavy duty shielding once you start passing many amperes through large transformers (yes, even if they are toroidal), their effects, while indeed very linear, are limited by the precision of the transformers, etc. So, good but bulky, heavy and expensive, and if they are to pass along really large currents (say, 10A and above), they need to be very heavy, and therefore even more expensive.

The second type consists of one or another arrangement of classic filters, using inductors, resistors and capacitors in some arrangement. These can be made quite easily (which is why they are by far the most popular type), can be cheap, are easily tweaked for any desired effect (filtering slope) and can be very compact (within power receptacles mounted on cases). But their faults are also many – their slopes are usually uselessly high, with any meaningful action starting at 120 kHz (way above where we really need them), their effects vary wildly from low to nominal power (typical losses can be as much as 6-10 times!), their filtering slopes are too slow (typically 6 or at best 12 dB/oct), their power handling is doubtful, and since they rely on the ground plane, they do in effect modulate it. In short, they are the cheap'n'dirty solution by and large, though there are some good ones around (and it probably won't surprise you to hear they cost and arm and a leg). And I haven't even come to the subject of phase shifts, which are murder on high dynamics expected from our power amps.

The third type are so-called floating or symmetrical filters. These have many advantages over both types described above, but also some disadvantages. Their power handling can be anything from low to incredibly high, 100 Amperes and more being no problem at all (if designed for it, of course), they can be much better as filters than the second type, and can be as good or even better than the first type, they do not use ground planes and hence neither depend on nor modulate the ground plane, and last but not least, need not be bulky and/or expensive. However, they also need to be made with some precision, ideally they should be calibrated for the desired effect, and cannot compete on price with the second type, even if the price difference is not too great, but are price-wise way better than the first type for the same power handling.

The last aspect you should bear in mind are specifications. Generally, audiophiles do not trust specifications because of their poor correlation with actual audible effects, but in case of line filters/conditioners, they should demand to see some specs. Ultimately, these specs do tell you how much any given unit will surpress line noise, and while that will not automatically make it a good audio choice, it will tell you what you are asked to lay out your money for. If you see something like say "-6 dB at 120 kHz", you will know that filter/conditioner is not doing anything worth mentioning where you need it, and if there is no explanation of the conditions of measurement, you won't even know at what power level that measurement was taken – very probably at very low power, to obtain better figures.

How much suppression do you need? Quite simply, as much as you can get, no two ways about it. But you need it at or below 20 kHz, where most of the electrical noise sources in from of electric motors are, not at 1MHz, where the relative power of any disturbance is incomparably smaller than at say 10 kHz (easily smaller by a factor of 1,000 or more). In short, look for specs covering the 5…50 kHz region, with the accent placed at the 5…20 kHz segment – THAT'S where you need it most.

Will you see such specs? Not at all likely. I've been researching this field for several months now, and I have seen actual specs stated only a few times for anything below 120 kHz. But they'll trip over themselves telling you what it does at 1 and 10 MHz, a region totally outside your audio equipment range.

But there are problems with line filters which cannot be avoided. One is speaking of their effects in absolute terms, which is virtually impossible, simply because it depends on how clean or polluted your own power line is, in itself a totally unpredictable factor. Another is that all line filters, no matter how they are made, will introduce some phase shifts. We don't know how much phase shift, perhaps much, perhaps very little. Depending on the type and quality of your power supplies, this will be a great problem, or no problem at all.

To give you an idea, C-core transformers are very sensitive to phase shifts, and even a small value may offset them, causing slowing down, lack of power and loss of dynamics. These are cheap'n'dirty transformers, which hardly anybody uses these days –

but I have come across them in some Japanese products, some of which were not cheap at all. By contrast, Chinese manufacturers, always assumed to be low quality, all seem to have turned to E-core transformers, just as Europe and USA did. Finally, toroidal transformers are generally not succeptible to this too much, but even then, much depends on how well they have been made. Point is, if you suffer a degradation, don't blame the filter first, rather investigate your power supplies before blaming the secondary cause of problems.

Fine, that's all talk, let's see some specifics now. So, I did some serious measuring before listening, and I won't bother you with what I've heard (usually little enough to make me wonder who but the totally misguided would pay that kind of money for that kind of next to nothing in terms of effects).

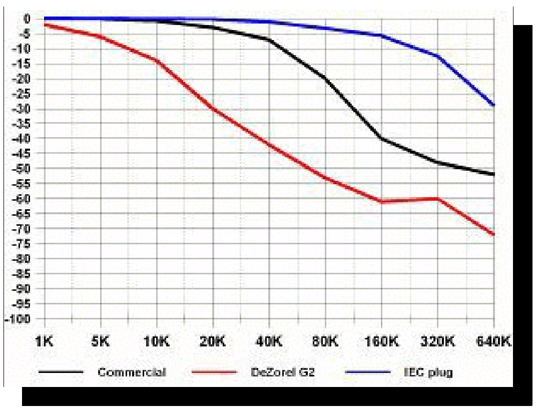
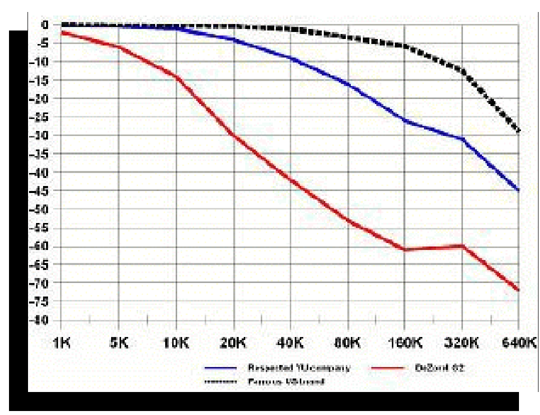


Figure 1 shows the filtering curves of so-called commercial filters, i.e. units not specifically made or advertised for audio use. As you can see for yourself, their effects were compared to the black box that started all this, the subject of this review, DeZorel's LFH-2 filter. Look carefully over the audio range, i.e. 5…20 kHz, then on to 40 or 60 kHz, where most of the powerfuly disturbances usually are. I think I can make no meaningful comment once you look over the picture. "Commercial" refers to a respected Swiss company, "plug-in" refers to a typical IEC power receptacle which also has a filter built in, and "DeZorel" refers to my sample of the test unit. At 10 kHz, the commercial filter is down by −0.8 dB (1.1:1 attenuation), the plug/filter by just −0.2 dB (1.02:1 attenuation), and DeZorel is down −14 dB (5:1 attenuation).

Figure 2 shows the curves of three filters specifically advertised as audio filters. Prices range from Euro/$ 80 to 600. Dotted black line is a product from a very famous US manufacturer ($600), blue line is a famous Yugoslav manufacturer of high end audio ($200), and red is my own sample of DeZorel LFH-2 ($ 199 or less, see third part of test). I think any comment is superfluous here.



Well, folks, that shows you how things stand in general. Please bear in mind that there are many line filters/conditioners on sale in the world, and the above results are not conclusive, only indicative. If you want to read what I heard from this filter and how it's made, read the second part of this report. If you have had enough of me, and want to read what our editors and readers from around the world had to say, read the third part of this report.

Part I of a three piece test published on TNT Audio (http://www.tnt-audio.com) site on 4 November 2001, and removed approximately two weeks later after an anonymous slur campaign was initiated against the author, Mr Dejan V. Veselinovic. We have subsequently learnt that a very unhappy competitor was most probably behind it. Unfortunately, the “Editor”, and in reality merely the owner of the site, went along with the campaign, even abetted it.

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