Want to try using your own combination of drivers in a hifi speaker system? It's really not hard to design your own low-pass, high-pass or bandpass filters, with either 6dB or 12dB per octave cutoff slope, to suit the drivers you want to use.

Remember that for a woofer (or subwoofer) you need a low-pass filter; for a tweeter, a high-pass filter; and for a mid-range driver, if you're using one, a bandpass filter. And to achieve a smooth overall response, without 'lumps' or 'dips' where the drivers take over from one another, you generally need to make the corner frequencies of their filters the same. So for a two-way system, for example, it's simply a matter of giving the woofer's low-pass filter and the tweeter's high-pass filter the same corner frequency — which becomes the crossover frequency, of course.

Whether you choose a 6dB/octave or 12dB/octave filter depends largely on the drivers you use, and whether they have any annoying behaviour outside their optimal frequency range, which might need the extra attenuation provided by a 12dB/octave filter. Otherwise, it's probably safer to stick with 6dB/octave filters and their smoother phase-shift performance.

Once you've decided on the corner frequency or frequencies, and the filter slope, you can if you wish work out the values for the various filter components you'll need for the filters from these formulas:

\[ L = \frac{R}{2 \pi f} \]

\[ C = \frac{1}{2 \pi f R} \]

where \( L \) is the filter inductance, in Henries; \( C \) is the filter capacitance, in Farads; \( R \) is the nominal impedance of the speaker driver, in ohms; \( f \) is the filter corner/crossover frequency in Hertz; and \( \pi \) is of course 'pi' (= 3.14159).

Rather than having to do a lot of calculations, though, in most cases you should simply be able to look up the values you'll need from the charts we've prepared below. These should save you quite a bit of time and effort.

**Practical considerations**

The best kind of capacitors to use in speaker crossover filters are metallised polypropylene types (for the smaller values) or non-polarised electrolytics for the larger values. Similarly for the inductors use air-cored coils for the smaller values and ferrite-bar assisted coils for the larger values (NOT iron-cored coils — they introduce distortion).

What if you need a filter capacitor value that's somewhere 'in between' commonly available values? The simplest solution here is to connect two capacitors in **parallel**, so their values add together to achieve the value you need. For example if you need a 13\( \mu \text{F} \) capacitor, you could connect a 10\( \mu \text{F} \) capacitor in parallel with one of 3.3\( \mu \text{F} \).

The same kind of thinking applies with inductors, except that here you connect two smaller inductors in **series** to achieve the desired value, not in parallel. For example if you need a 14mH coil, you could use a 9.0mH and a 5.6mH coil in series.

Note that in each of the above examples the resultant values are not exactly those needed, but they're 'close enough'. Generally you don't have to be highly accurate with crossover component values — in most cases a value within 5% or so of the calculated value (or the value shown in the charts) is fine. That's because speaker driver impedance varies quite a bit from the nominal value anyway, and also varies with frequency.
Speaker connections & impedance matching

When you're designing your own speaker systems, one of the things that can make life complicated is impedance matching considerations. For example you may have some very good 8Ω speakers you'd like to use, but your amplifier is designed to deliver its maximum output into 16Ω loads. Or alternatively you may have some excellent 8Ω speakers, which you want to use with an amplifier designed for 4Ω loads. Or perhaps you just want to use multiple speakers on each channel of your system, to boost its power handling capability.

In most cases the solution is to connect your speakers in either series, parallel or series/parallel, as shown in the diagrams below. As you can see with speakers in series their impedances simply add together, like resistors — so two 8Ω drivers in series will produce 16Ω. Or connected in parallel, they'll produce 4Ω. Or if you connect four 8Ω speakers in series/parallel, they'll produce a resultant impedance that still presents 8Ω to the amplifier, but your speakers can now handle approximately four times the power.

Note that when you connect multiple speakers together in these ways, you need to be careful with their polarities — as shown in the diagrams. This is to ensure that they don't 'fight' each other in terms of their sound output, but 'push' and 'pull' together...

Finally, the last diagram shows how speakers are hooked up in public address systems using the ‘100V line’ system. Here they're all connected in parallel across the 100V line, but via their individual matching transformers. The amplifier has a transformer too.

(Copyright © Electus Distribution, 2001)