My XSim crossover development procedures:

1) I use OmniMic and DATS V2 for all tests.

2) I build the speaker box and mount all drivers.

3) I drill a small hole in the back of the speaker and run a pair of wires to each driver and out the back. I seal the hole temporarily where the wires come out with a small dab of caulking.

4) I set OmniMic up in my great room, which has a sloped ceiling leading to a loft area. All reflective surfaces are at least 5 to 6 feet away from the mic and speaker, except for the floor, which is always much closer.

5) I usually position OmniMic 26" to 39" away from the speaker, directly on axis with the tweeter dome. The taller the speaker, the further away I position the mic.

6) Sometimes I put the speaker on top of my DIY horizontal polar table (17 inches high) and sometimes I put the speaker on a stand. If a tower speaker, sometimes I place it directly on the floor so that the mic picks up the proper floor boundary gain effect. Remember that the amount of baffle step compensation (BSC) that I apply later is greatly influenced by how high I place the speaker during measurements!!!

7) I hook up a good amplifier and CD player and run a pair of wires to the back of the speaker. The amp and CD player tone controls are always defeated or set to "FLAT". I do not use my internal laptop CD player or small digital amp.

8) If you are measuring a true transformer coupled ribbon tweeter, insert a 33uF or 50uF non-polarized electrolytic protection capacitor in series with the tweeter for all tests. For other types of tweeters, a series protection capacitor should not be necessary.

9) I hook the amplifier to the woofer first, carefully observing + and – polarity.

10) I insert the OmniMic test CD into my CD player and play track 2, sine sweep.

11) I set OmniMic to sine sweep, blended mode, 5ms gate, 1/48th octave smoothing, phase on.

12) I adjust the amp volume to a moderate level that seems like it will not damage the drivers, especially the tweeter.

13) VERY IMPORTANT: Once I set the testing volume level, I DO NOT change the volume level during any of the tests listed in step 15 below.

14) If I do decide to change the volume level for some reason, perhaps because it sounds too loud on the tweeter, then I go back and re-do all step 15 tests from the beginning using the same volume level for all drivers.

15) I take a FR measurement, then I pause OmniMic, then I pause the CD player, and then I click 'save curve" as an FRD file for all driver combos as follows:

A) Woofer alone.FRD
B) Midrange alone.FRD
C) Tweeter alone.FRD
D) Woofer+Midrange.FRD (paralleled up connection to amp)
E) Woofer+Tweeter.FRD (paralleled up connection to amp)
F) Midrange+Tweeter.FRD (paralleled up connection to amp)
G) Woofer+Midrange+Tweeter.FRD (paralleled up connection to amp)
NOTE: I hit the CD player pause button quickly, after only 2 to 3 sweeps, when making measurements C, E, and G above so as to minimize stress on the tweeter's voice coil.

16) I am very careful to observe polarity + or - for all step 15 tests.

17) The number of step 15 tests will be reduced from 7 to 3 for a 2 way build.

18) I am also very careful not to move or bump the microphone or speaker during all step 15 tests.

19) This gives me a complete set of on-axis FRD files that can be used to develop a new crossover.

20) Now I need a complete set of ZMA files for each driver measured "in box"

21) I use DATS V2 to run an impedance sweep on each driver alone, and then export the curve using a zma extension as follows:

A) Woofer in box.ZMA
B) Midrange in box.zma
C) Tweeter in box.zma

22) Note: I do not use a series protection cap on the tweeter for the zma test, as this is a very low power, single sweep type test.

23) I load the XSim program, and, on the schematic CAD screen, create a 3 way connection of tweeter, midrange, and woofer to the amp with no crossover parts, just hard wire connections between amp and drivers. See the attached screen shot example of what this schematic looks like.

24) I then click on each driver icon to bring up the driver's input dialog box and enter the appropriate "alone.FRD" and "driver.zma" files for the 3 drivers that I created in step 15.

25) Once I start entering the FRD and ZMA files, a strange looking, composite type, frequency response graph starts to show up on the frequency response graph. This looks like a bad response, but this is OK and normal.

26) Once this is done, I set the "mod delay" offsets in XSim using the "Get file" overlay procedure as outlined in the next few steps.

27) On the top of XSim's frequency response graph, I click curves, then “get file”, then load the Midrange+Tweeter.FRD file in, which then overlays this file on top of the modeled graph.

28) On the CAD schematic screen, I connect the tweeter and midrange icons, but temporarily disconnect the woofer icon.

29) Now the goal is to adjust the "mod delay" of the tweeter until the model and the "get file" overlay match as closely as possible. Again, since this is a measurement of the tweeter and midrange alone, I temporarily disconnect the woofer on the schematic CAD screen.

30) When the two curves match as closely as possible, the "mod delay" is correct for the tweeter driver dialog box.

31) I repeat this same "get file" matching procedure for all combinations of measurements and possible crossover model connection possibilities. When done, I have a "mod delay" setting of some value for the tweeter and woofer, but NO "mod delay" setting for the midrange. The midrange is considered the anchor driver and does not require a "mod delay" adjustment.

32) Once I have the "mod delays" set up, I am ready to start developing the crossover. But before starting, I must establish the SPL of the 100-300Hz region so that I can decide on the amount of baffle step compensation (BSC) to apply. This is not an easy thing to do, because the FR measurements below 400Hz are bouncing up and down due to room gain and boundary reflections.

33) One method used to establish the 100-300Hz SPL level would be to take near field (NF) frequency response measurements of your midrange and woofer drivers and then merge them with the far field (FF) measurements using the blender program. If I decide to use this procedure, I need to replace all “as measured” phase data in my model with minimum phase data.

34) Another method would be to apply 1/3 octave smoothing to all frequencies below 400Hz and then splice this data into the far field curves. With experience in looking at how the response rises or falls from 1000Hz to 100Hz, I have found that I can, with reasonable accuracy, estimate the amount of baffle step needed in this manner. I also adjust the amount of BSC applied based on the amount of floor boundary reinforcement in my measurements, which varies with microphone testing height.

35) I then develop my crossover by inserting capacitors, inductors, and resistors in series and/or parallel with my drivers. As I do this, the frequency response and impedance curves change instantly, so I can see if I am moving in the right direction.

TIPS:

A) Recently, I have begun to use dlr's new winfilters program to generate target curves, importing them into XSim using the FR window's “get file” drop down menu.

B) I watch the impedance curve closely as I make changes to make sure the impedance does not drop too low (below 3 ohms or so) with a high negative phase angle. From what I have read in the forums, a high negative phase angle with low impedance is considered to be a very difficult amplifier load.

C) As I design, I click on the frequency response curves drop down menu and then load the various drivers with phase curves onto the screen. I turn off the system and woofer phase curves to remove clutter. I watch the phase curves for the tweeter and midrange and try to get the very best "phase tracking" on these drivers. I want the curves to be parallel or overlapping throughout the crossover region. If these curves are non-parallel, then the crossover model will not sum properly.

D) If I plan to use the speaker well away from the rear and side walls, then I try to apply the full 6dB of baffle step compensation (BSC). If I plan to put the speaker near a back wall, then I apply much less BSC. Also, if I place the woofer very close to the floor in my design, I have found that much less BSC is needed, due to the floor boundary reinforcement effect. From what I have read in forum threads and white papers, one of the best ways to adjust the amount of BSC is to increase (or decrease) the value of the woofer's series inductor. This helps to adjust the balance and slope of SPL levels in the 100 to 1000Hz range.

E) I often repeat step 15 measurements above for other microphone positions. This makes it possible to perform horizontal and vertical polar response simulations in addition to on-axis simulations. When I do this, I am careful to use the “get file” overlay procedure again to re-set “mod delays” for each microphone position. Every time the microphone or speaker is moved, the relative distance from mic tip to individual driver VC changes as well.

F) I have also changed the FRD phase source from “as measured” to “derived” which brings up a “define response tails” dialog screen. This replaces the “as measured” phase with minimum phase data. I can then export the revised minimum phase FRD files and import them into other modeling software packages, such as PCD or WinPCD. This allows me to run polar response simulations, once I have the x,y,z driver coordinates set up properly.

G) I can switch back and forth between “as measured” phase and “derived” phase in Xsim, but when I do it is necessary to repeat the “get file” overlay matching process to adjust the “mod delay” settings each time.

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