Subject: 4Pi crossover study
Posted by Joe Sever on Fri, 19 Jul 2013 02:17:55 GMT
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After having spent several months biamping with MiniDSP, I have for several reasons decided to go the passive route (or at least away from MiniDSP). Given that my "design" is inspired by the 4Pi, along with the flexibility of its crossover, I figured I'd give Wayne's crossover a shot. However, despite some reasonable success with the MiniDSP, the 4Pi crossover is not doing what I expect (or at least would like) it to do. A 45 SET amp supplies the input to the crossover.

The speakers:
5.5 cu. ft. box tuned to 39.5Hz
Omega Pro-15A
Radian 475PB on SEOS-12 waveguides

Crossover details:
R1 = single 30 ohm 10W resistor
R2 = single 13 ohm 10W resistor
Rs = none
C1 = none, though several values from 0.33uF to 6.8uF have been tried

Here's the problem: Measured 1M from the speaker baffle and midway between the LF & HF drivers, the frequency response rolls off in a linear fashion, beginning at 6KHz or so and ending about 12dB down at 20KHz. I would expect this without the compensation EQ in place, but not with it. I think the attenuation around 6KHz is correct - it's just the lack of rolloff compensation that has my stumped. To rule out a bad driver, I measured the other speaker with the same results.

I know that Wayne has compared the SEOS-12 and the H290C side by side on the DE250, and the SEOS-12 showed a steeper rolloff than his horn, but not to the degree that I'm seeing.

Here are what I see as my options:
1) Buy Wayne's horns and hope that that alone will solve the problem.
2) Try a different driver. I've tried the DE250 in the past and didn't like it. I have a Faital HF10AK on hand that I haven't listened to yet.
3) Scrap the 4Pi crossover and try something else.

I'm leaning toward #1, but deep down I don't believe that's the answer. There has to be something fundamental I'm missing, but I've been over the circuits and Wayne's various docs and I'm at a loss.

Even with its current shortcomings, this crossover blows the MiniDSP out of the water, so I'm hoping that with some tweaking I can come up with something I can live with.

Thanks in advance for any help anyone can lend.

ripple. Designers using this horn usually incorporate notch filters to get decent response. To me, this is a deal breaker. That's why I did not adopt that horn in my designs.

You can use notch filters to smooth the response, but I don't think it sounds right on any horn I've ever used with this same problem. I walked away from horns like that years ago for this very reason.

The SEOS ripple is about 5dB, and it is definitely audible. So the crossover needs to do something about it. When Erich asked about the notch filters in the crossovers his designers were using, Bill Waslo said this:

"It's those Inductor-Capacitor-Resistor (LCR) strings that go across the CD driver. Can't just take them out, other stuff would need to be adjusted to compensate or it would sound awful. I did run some designs without those LCR, but really think they should be left in. One of the bumps they deal with is at 2kHz, which is a terrible frequency to have a bump at (near where ears are most sensitive)."
Bill Waslo comments on the audibility of the ripple inherent in the SEOS deviceIn contrast, the H290C is smooth, only having about 2dB ripple. It doesn't need notch filters to sound good. This

conjugate mass-rolloff. It is extremely flexible in this regard, provding a way to set the damping in the crossover region, which sets the SPL in the first couple octaves independently of the augmentation used for mass-rolloff compensation. But it doesn't provide any mechanism for mitigating response ripple.

Speaker motors and passive crossover filters
Crossover Electronics 101 Seminar Handout
Phase angles, crossovers and baffle spacing
Baffle spacing, phase angles and time alignment, revisited
Tweeter circuits for constant directivity horns and waveguides
Crossover configuration
Spice crossover models
DI-matched two-way loudspeakers
Crossover optimization for DI-matched two-way speakers
Crossover optimization for DI-matched two-way speakers, revisited
One more thing: When you work with a horn/waveguide, you have a funny impedance curve that can sometimes interact with the crossover and create peaks, even if the horn/waveguide response is smooth when connected directly to the amp. This is especially true when padding is used, as is usually the case. But the impedance peaks can easily be damped with a snubber resistor, much the same way a Zobel is used on woofers. You see this in some waveguides, like the QSC and the H290C. I really like it when even those impedance peaks are below the passband, but it isn't really a problem if it's above crossover, it's just that you'll need a snubber resistor or Zobel to flatten the impedance curve.

But when you use a horn that has a lot of ripple, you either have to use a bunch of notch filters, or you have to accept the ripple.  Neither one is acceptable to me.  I would rather use a horn/waveguide that has smoother response.

H290C compared with SEOS12

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Subject: Re: 4Pi crossover study
Posted by gofar99 on Fri, 19 Jul 2013 03:18:47 GMT
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Hi,  I'm sure some one else will chime in with ideas, but my first thoughts are regarding how you are measuring the levels.  Two things particularly, the physical location for the mic.  It could be in a null region or off axis of the main sound pattern.  Second the actual equipment used to do the measuring.  I have a shop full of gear and still get mixed results when I look at the stuff above 10K.  It really doesn't matter what source, which speakers or exactly where I do the measuring.  The room seems to cause the problem.  The sound is there, I can sweep the spectrum and hear it (up to about 14K then my ears go south).  So I figure that if something measures well at 10K it is likely just fine above that.  BTW I have used Wayne's crossover in a pair of 7 cubic foot cabinets (tuned to 24 HZ) with a Goldwood 15 inch woofer, Wayne's horn and the Eminence drivers.  Great sound.

EDIT:  I see that Wayne answered at the time I was writing.

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Subject: Re: 4Pi crossover study
Posted by Joe Sever on Fri, 19 Jul 2013 12:08:53 GMT
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Thanks for the reply, Bruce.

Two other possibilities have occurred to me.  One is, as you suggest, that my mic is in a null - I'll check this evening.  I'm actually hoping this is the case, though I think not given the linear nature of the dropoff and that it gets worse at the upper extreme of the response.

The other is that the amp's OPTs are rolling off.  I really doubt the latter as others have measured them as ruler flat.

FWIW I'm using REW, with a calibrated Dayton EMM-6 mic through an MXL USB Mic Mate.  I've been measuring in my small room with the speaker in its normal listening position; I really need to lay it on its back, though that may just clean up the hump and dip (floor bounce?) that I see well below the crossover point.

Wayne - Many thanks for your input.

While I appreciate that the SEOS may be introducing ripple on top of my other issue(s), my approach is to address one issue at a time. I'm certainly not married to this particular horn.

My primary issue at the moment is that the mass rolloff doesn't appear to be touched by the compensation circuit - it's an obvious 12dB dropoff from 6K-20K. My fear is that while another horn may be a better bet in the long run, I'll still be left with this weird rolloff to deal with.

I'll post some images of the measurements - maybe something will jump out that I'm not adequately describing. And though I hate to disturb my pretty soldering, I should probably also measure without the compensation circuit in place to see what, if anything, it's doing.

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Subject: Re: 4Pi crossover study
Posted by Wayne Parham on Fri, 19 Jul 2013 17:12:45 GMT
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I think it is smart to tackle one issue at a time. The way you're going about it is good. It's just that I also think if you get the response right for the SEOS, it won't be right for the H290C and vice versa. The biggest difference is the ripple, but the rolloff slope is different too.

A horn with constant directivity will present the response of the driver, unmodified. So mass-rolloff is there. However, if the horn either increases directivity or increases efficiency as a function of frequency, then that will provide some acoustic equalization. Also, some drivers don't have as much mass-rolloff as others.

High-end rolloff is largely a diaphragm thing, not just mass but also flex modes. Sometimes you'll see mass-rolloff countered by damped breakup, and this can increase the top end. Where there isn't enough damping response is rough, but if the diaphragm has enough internal self-damping, response is smooth and it just looks like the driver has extended output. In any case, the top-end response of some drivers shows more rolloff than others.

output in the top two octaves. It also lets you set the amount of augmentation in the top two octaves.

that have a waveguide/horn use this same basic circuit topology.

Top-octave compensation is set mostly by the R1/C1 values, but it is also affected by voice coil inductance and the amount of damping from the Rs resistor, if used. Voice coil inductance tends to increase rising response. A shunt value in the Rs position tends to reduce rising response. And of course, the use of capacitor C1 increases rising response, and also sets where it begins.

The optional shunt value Rs is used for horn/driver impedance control. If the impedance peaks are all below crossover, then resistor Rs isn't needed. But if there are impedance peaks above crossover, then they will need to be snubbed by a resistor in position Rs. It's like a Zobel. The value is generally around 2x the DCR of the compression driver, which prevents the Zmax from rising too high. One could also use an inductor in series with Rs, and then use a lower value resistor. But I find the resistor by itself is sufficient.

The bottom octave shelf is created mostly by the value of R2. When it is high, the damping is reduced, boosting output near crossover. This is what creates the shelf. Where the shelf isn't needed, the R2 resistor should be set low, to provide more damping. Increased damping (using lower R2 value) can also be used to counter an impedance spike, similarly to Rs. But R2 is providing damping for the crossover, not the driver. So it acts differently than Rs, in that it isn't modifying the driver's impedance. Being ahead of R1/C1, resistor R2 is more effective at modifying the transfer function within the crossover region, whereas Rs is more effective at modifying the curve above the crossover region. Again, Rs is used just like a Zobel.

Balanced with all this, the R1/R2 ratio sets the overall attenuation. You have to set R1/R2 values that give the right attenuation for matching the tweeter output to the midwoofer, while simultanously setting R2 for the right bottom octave shelf, and R1 and C1 for the right top-octave augmentation.

This is the basic transfer function we are looking for. It may need a little more or less overall attenuation, or a little more or less top-octave augmentation. It may need more output in the bottom shelf, or maybe a little less. You may need to use impedance compensation, or you may not, depending on the horn and driver, whether or not it has impedance peaks above crossover. But in general, this is what we're looking for, which is appropriate for any constant directivity horn that doesn't have excessive ripple:

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Subject: Re: 4Pi crossover study
Posted by Wayne Parham on Fri, 19 Jul 2013 18:55:42 GMT
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One more thing:

You and Bruce are focused on the measurement setup, and that's good because you should really start there. I am focused on the crossover and the horns and drivers, because that's the subject we're trying to understand. But really, if you're seeing more rolloff up high than you expect, it is just as likely the microphone or measurement setup as it is the device under test.

Do you have any way to baseline the measurements? Do you have a known source that you can test and see if there is rolloff up high? I expect you would have done that already if available, but it doesn't hurt to ask.

The compression driver itself may rolloff more than you are expecting too. The JBL drivers

certainly do, which is why they need more compensation.  That's not a bad thing, as it indicates reduced or highly damped breakup.  But ideally, we have the output up high and it's smooth.  We want to have our cake and to eat it too.

Anyway, try and find a way to baseline your measurements, so you can know whether or not to trust them where rolloff is concerned, or if maybe they're showing more rolloff than is really there.  If you can validate the measurement setup is accurate, then try to find the cause of the rolloff in the DUT by swapping it - Change things one at a time until you find the cause.

I'd start with the compresion driver first, if possible.  Borrow a different driver if you can, and see how that tests.  If that's not possible, try some really basic filters and see how they act.  First, try no filter - straight wire to the driver.  Then try a basic first order, just a capacitor in series.  Then try putting in a resistor shunted by a capacitor in series, the R1/C1 part of the network.  This should give peaks where there are impedance spikes, but should also give rising response.  Then put a shunt resistor in there to damp the impedance spikes.  Build up one step at a time to see what each part does to the system response.  Let the documents below be your guides:
Speaker motors and passive crossover filters
Crossover Electronics 101 Seminar Handout

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Subject: Re: 4Pi crossover study
Posted by Joe Sever on Fri, 19 Jul 2013 19:41:28 GMT
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Thanks for the additional info and suggestions, Wayne.  Great stuff here - I have my work cut out for me...

Your penultimate post helped me to understand how R1, R2 & C1 each contribute to the augmentation.  I've read it all before, and it made some sense, but for some reason a rewording helped it all fall into place.

Anyhow, I'll do what you and Bruce suggest and report back.

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Subject: Re: 4Pi crossover study
Posted by Joe Sever on Sat, 20 Jul 2013 23:11:13 GMT
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The plot thickens...

This time I measured with the speaker on its back, and the mic directly over the Radian's diaphragm about 19" away.

I took two measurements: one through the unmodified crossover, and the other directly from the amp to the speaker.  The measurements were the same!

So either I've miswired the crossover, or my measurement setup is faulty.  Unfortunately I don't have any other speaker available for reference, otherwise I'd measure it.

Though I suspect the measurements themselves at this point, here's the crossover for scrutiny:

File Attachments
1) DSCF3751.JPG, downloaded 14832 times
2) DSCF3752.JPG, downloaded 14635 times
3) seos measurements.jpg, downloaded 14669 times

Subject: Re: 4Pi crossover study
Posted by Wayne Parham on Sun, 21 Jul 2013 00:30:54 GMT
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As an extra sanity check, make a noise floor meaurement, i.e. one where no sound is made.  See what that gives you.  You might also try taking measurements of the speaker in way-off states, like muffled by a pillow, through a small value cap that tips up the response, etc.  See if you can see those kinds of large changes.

Subject: Re: 4Pi crossover study
Posted by Joe Sever on Tue, 23 Jul 2013 00:23:25 GMT
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Just checking in - been spending most of my spare moments enjoying the cooler weather and live music streams...

Not exactly what you suggested, Wayne, but I did see some movement when trying different values in the C1 position:

Moving forward my plan is to procure a cheap piezo tweeter, to see if the rolloff is there with a completely different device with an extended range.

When time permits, I will try a first-order XO and build from there to see what each stage does to the response.

I do have a different compression driver on hand to play with, similar in efficiency to the Radians. Unfortunately I don't have mounting studs for it as they are a tad smaller than those on the Radians (but the same size as those on the DE250).

File Attachments
1) c1 diff values.jpg, downloaded 14548 times

Subject: Re: 4Pi crossover study
Posted by Wayne Parham on Tue, 23 Jul 2013 06:21:48 GMT
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We can definitely see the response change corresponding to C1 value changes. So that's good, to be expected. But for whatever reason, the system takes a nose dive at 8kHz or so. It will be interesting to see if all tweeters show this trend (indicating a likely measurement anomaly) or not (indicating a tweeter problem). Thanks for keeping us posted.

Subject: Re: 4Pi crossover study
Posted by Joe Sever on Wed, 24 Jul 2013 02:16:28 GMT
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I just remembered that my daughter had a little Samson USB Mic, so I thought I'd give that a go just for grins.

It's too late to do any serious measurements or super accurate mic placement (and I forgot to save the couple measurements I did do), but with the crossover in place (no C1), more or less on axis, roughly 18" from the CD diaphragm, the freq resp from 3K-20KHz is actually tipped up!

More measurements tomorrow. In the meantime, I'll resist the urge to throw my USB mic pre in the lake.

Subject: Re: 4Pi crossover study
Posted by Wayne Parham on Wed, 24 Jul 2013 03:08:26 GMT
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Very good. Now you can have another run at it.

Subject: Re: 4Pi crossover study
Posted by Joe Sever on Thu, 25 Jul 2013 01:09:53 GMT
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Not out of the woods yet.

Here's 20-20K on the standalone USB mic. The downward trend from ~7K-20K is clearly there:

So I'm starting to feel more confident of - but more discouraged by - the previous measurements.

Once I scare up some way to mount the other CD I'll see how it measures.

File Attachments
1) samson.jpg, downloaded 3802 times

Subject: Re: 4Pi crossover study
Posted by Wayne Parham on Thu, 25 Jul 2013 02:10:01 GMT
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Interesting. The response from the SEOS12 is as I would expect between 1kHz and 6kHz, but above that, it has more rolloff than it should have just from mass. There's 20dB drop from 6kHz and 10kHz, more than 18dB/octave. This would only happen if voice-coil inductance and the front chamber conspired to rolloff at the same point, and they're usually staggered, with mass starting around 4kHz, inductance around 12-16kHz and front chamber just above that.

Could be that the phase plug is blocked with debris, or maybe the diaphragm is misaligned. You might open the compression driver and check it out. Sometimes just taking it apart and putting it back together fixes that kind of thing.

Subject: Re: 4Pi crossover study
Posted by Joe Sever on Fri, 26 Jul 2013 20:46:06 GMT
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Tried the other CD I had on hand, and the results floored me:

While I have some work to do on the cabinets (bracing, damping of standing waves, etc.) and perhaps more traps in the room, I think we're done here. That said, I'm always open to suggestions...

Thanks, Wayne, for your guidance and support.

File Attachments
1) hf10ak.jpg, downloaded 3816 times

Subject: Re: 4Pi crossover study
Posted by Wayne Parham on Sat, 27 Jul 2013 15:01:38 GMT
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Yes, that looks good.  The other driver must be messed up.

Can you send it back for a warranty replacement?  If not, you might want to take it apart and see if there is debris in the phase plug.  Make sure it is clear and free of dust.  Sometimes just taking it apart and putting it back together recenters the voice coil and fixes problems like these too.