Subject: An amazing listening session with the H290C
Posted by Bill Epstein on Thu, 18 Apr 2013 03:54:48 GMT
View Forum Message <> Reply to Message

Had a lot of trouble working the new horn into my 4 Pis, partly because a Jelco SA-240 tone arm arrived and muddied the water at about the same time.

Initially, the H290C was bright sounding. I asked Wayne about it and he'd recently determined the DE-250 needed a shunt resistor, which I added. Without taking much time and wanting to hear my new tone arm, I committed the cardinal sin of making 2 changes simultaneously. Thinking something was amiss, I came across a post here that advised removing the C1 Capacitor from the 4 Pi crossover. Made it happen.

A lively system lost some luster. That sucked because it takes much more effort to solder caps back in than to snip them out.

Sunday morning I reinstalled the Obbligato .47s.

Today, after a suitable warm-up of the Caravaggio Phono Stage and DIY single-ended KT-88 (Gold Lion Kinkless Tetrodes Rule!!!) amp, I played the Markevich Tchaikowsky Second, "Little Russian" Symphony. Marvelous! Things hinted at during the period of changes became solid: improved image, instrument timbre and especially hearing portions of the score that are usually buried too deep in a recording but are important parts of the texture, none the less. There's more to that than simply hearing more detail, more than that hackneyed "I'm hearing my albums again for the first time", thing. I hear openness and clarity beyond even improved ambience; the recordings sound more "alive".

Next came the greatest favor you can do for your rig after a major change, the Chesky re-issue Sibelius Second Symphony, Barbirolli/Royal Phil. The music is jazzy, the recording by Wilkinson, superb and the orchestration creates kind of a "Guide To The Symphony Orchestra" in the imaginative ways Sibelius combines and utilises sections of instruments. There were goosebumps for the final 16 bars.

The H290C improves the 4 Pi.

Subject: Re: An amazing listening session with the H290C
Posted by rkeman on Thu, 18 Apr 2013 12:06:18 GMT
View Forum Message <> Reply to Message

Time for Wayne to chime in! So is the correct crossover change with the H290C and B&C DE250 combination removal of the capacitor C1 and addition of a 16 ohm shunt resistor across the tweeter or not? The flattest response curve is the goal. Five brand spanking new horns are waiting on the answer because doing this project twice is not an appealing option.

Subject: Re: An amazing listening session with the H290C
Posted by NWCgrad on Thu, 18 Apr 2013 13:28:50 GMT
View Forum Message <> Reply to Message

Will be following as I still need to complete my center channel 4 Pi, would need to replace the old style waveguide with the new on all three speakers. Didn't know about requirement to change the crossover.

Subject: Re: An amazing listening session with the H290C
Posted by Wayne Parham on Thu, 18 Apr 2013 14:26:35 GMT
View Forum Message <> Reply to Message

You definitely want the Rs resistor installed and the C1 capacitor removed. This provides the best response. Of course, you can always leave C1 in place, but doing that gives a slightly tilted-up response, totalling about 3dB more at the very top end.

The beauty of DIY is you can tweak to suit your taste. I think that is what Bill is saying here. He likes his speakers to have a smidge more up top. It's not a huge difference, subtle, but definitely audible. You can always try it both with and without C1 and see how you like it each way. But if flat amplitude response is your goal, remove C1 because it definitely measures flatter.

Resistor Rs is actually there just to shave off Zmax. I've used snubber resistors like that in many designs. Search "Zmax" here and you'll see lots of discussions about this over the years. Its purpose is mostly to make the design more robust, more tolerant of operating shifts and unit-to-unit variations in compression drivers.

After the H290C upgrade, internal reflections are reduced to best-of-class levels and response is very smooth. Other waveguides don't have the right shape (flare profile and ratio of length to mouth area) to give such smooth response. Ours is ruler flat. See measurements in the thread below, at the top of the second page.
H290C Horn/WaveguideA little more tech talk, history of the development of the H290C:

Waveguides have a lot in common with conical horns, which have been a specialty of mine for over 30 years. I've made conical horns and waveguides for every frequency range - tweeters, midrange and even some midbass units. One thing I've learned is that throat area and length are as important as mouth area in a conical horn or waveguide. That fact seems to have been lost on some, who see these devices purely for their directional control.

It is interesting for me, because for many years, most other hifi horn implementers were more concerned with acoustic impedance than directivity. Seemed like directivity was a side-effect to them. So in that environment, I was probably more concerned with directivity than most others. However, I have seen a shift in recent years towards directivity as the primary focus, much like it is in the prosound world. Here, I find myself talking more about the acoustic load, because I think many newer horn/waveguide hobbyists have overlooked its importance.

Directivity and acoustic impedance have a symbiotic relationship. Things that affect one almost always manifest themselves in the other. Where there are impedance peaks, you can usually find ripples in directivity. And where you see directivity shifts, you usually also see response and impedance ripple. They all tend to reflect upon one another.

Conical horns and waveguides create a radiation pattern that is defined by the wall angle, for the most part. However, at the low end of the range, directivity narrows, becoming smaller than the wall angle. And below that, it opens wide up. This directivity shift can be seen in the response and impedance curves. It also shows up on a baffle, by the way, which is essentially a 180° waveguide. That's basically what causes the so-called "baffle step". But I digress.

The throat area, mouth area and length all play an important role too. A horn has to be long enough to provide adequate acoustic load at low frequencies and it has to have enough mouth area to release the wavefront without excessive reflection. This mouth termination is really important, as is the length, especially in a conical horn or waveguide, since loading is compromised at low frequencies.

A truncated horn creates a reflection at the mouth. When severe, it can adversely affect the entire passband. In contrast, diffraction at the mouth edge only affects the lowest frequencies. So reflections caused by having an abrupt mouth termination from a truncated horn are far more objectionable than edge diffraction at the mouth.

While it is attractive to radius the mouth edge, it definitely shouldn't be given a higher priority than acoustic loading. A radiused mouth edge helps smooth the directivity transition at the low end of the range, where the horn/waveguide waistbands and then goes omnidirectional. But the radius does nothing from midband up.

This is why the H290C flare profile is purely oblate spheroidal, having length/area ratios that provide smooth response and only the edge at the mouth radiused. It has no secondary flare, no opening up at the mouth. It provides nearly constant directivity without sacrificing sound quality.

If you set wall angle and throat area as fixed dimensions, then mouth area is a function of length. So in a way, you can think of a horn/waveguide having cutoff based on its throat size and wall angle. These become constants, since mouth area is set by length. The length sets the mouth area (or vice versa), which largely determines acoustic loading characteristics, and ultimately sets the amount of response ripple.

This also has an indirect effect on compression ratio, since the throat area compared with the diaphragm radiating area set compression ratio. The best designs strike a balance between compression ratio and throat area, to obtain good acoustic loading and maximize efficiency/bandwidth ratio while simultaneously minimizing ripple through proper choice of throat size. Because, again, throat area and wall angle make mouth area versus length become contstant.

Of course, mouth area can be increased using a secondary flare. As mentioned above, this is sometimes done to counter waistbanding, almost always in prosound horns. But this does not increase length, which is vitally important in a conical horn or waveguide, to provide adequate acoustic loading. So there are competing priorities in that regard.

Mouth shape sets mouth area too, with a round or elliptical mouth using less baffle space as mouth area. This tends to favor rectangular horns, since they make use of all available space to improve the mouth termination and reduce internal reflections. But a round or elliptical mouth can be made to work too, it just has to be larger and longer to maintain parity.

My point is there are competing priorities in horn/waveguide design, and I personally would never choose a design that optimized directivity at the expense of acoustic response. I wouldn't discount directivity either, of course. That's the main reason I prefer radial horns and waveguides, for their superior directional characteristics. But I think the point is we're not looking for array-ability in a high-fidelity waveguide, we're looking for quality when implemented in a DI-matched two-way speaker, crossed to a midwoofer, or constant directivity cornerhorn, crossed to a midhorn. We're looking for superior sound when used in a high-fidelity speaker. Based on years of study in conical horns and waveguides, I believe the H290C is the absolute best choice for designs of this type, the best size and shape for a high-fidelity tweeter waveguide.

Subject: Re: An amazing listening session with the H290C
Posted by Ash R on Tue, 23 Apr 2013 15:17:23 GMT
View Forum Message <> Reply to Message

Wayne Parham wrote on Thu, 18 April 2013 09:26
The throat area, mouth area and length all play an important role too. A horn has to be long enough to provide adequate acoustic load at low frequencies and it has to have enough mouth area to release the wavefront without excessive reflection. This mouth termination is really important, as is the length, especially in a conical horn or waveguide, since loading is compromised at low frequencies.

Just out of curiosity, is there any benefit gained from decreasing waveguide depth?

Subject: Re: An amazing listening session with the H290C
Posted by Wayne Parham on Tue, 23 Apr 2013 15:38:58 GMT
View Forum Message <> Reply to Message

No, none. Well, a shorter device can be mounted in a smaller cabinet, so I suppose that might be useful in some cases. But qualitatively, no. There is no benefit in having a waveguide shorter

long, the horns must be compromized due to physical constraints. Tweeters should never be designed this way, because wavelengths are short enough that they can be made full size and not compromized.

In fact, JBL makes two versions of its Progressive Transition waveguides, one that is longer which they call "optimized" and another that is shorter, purely done so they can fit it into smaller cabinets.

Subject: Re: An amazing listening session with the H290C
Posted by Ash R on Tue, 23 Apr 2013 17:21:50 GMT
View Forum Message <> Reply to Message

Sorry for the tangent but somewhat related, IMO:

On another web site, there's a lot of scuttle about a short waveguide. No need to mention it by name.

Some measurements show what you're talking about, a lot of ripple in the response, but other measurements don't show it as bad. Any idea why that might be?

Subject: Re: An amazing listening session with the H290C
Posted by Wayne Parham on Tue, 23 Apr 2013 18:28:10 GMT
View Forum Message <> Reply to Message

Ash R wrote on Tue, 23 April 2013 12:21Sorry for the tangent but somewhat related, IMO:

On another web site, there's a lot of scuttle about a short waveguide. No need to mention it by name.

Some measurements show what you're talking about, a lot of ripple in the response, but other measurements don't show it as bad. Any idea why that might be?
Could be a lot of things:

1. Different compression drivers. The rear chamber can be sized to provide reactance annulling, which will smooth response down low. It sort of fills in the first hole, right above cutoff. But in truth, this is probably not going to be effective on a 90° waveguide, because most 1" compression drivers are tuned too low.

2. Different environment and boundary conditions. If a waveguide is measured on a baffle and also in free space, the free space measurement will probably show more ripple. Polars are different too. This is less the case for very large devices and more apparent on smaller ones.

3. Drive circuits. Current sources expose impedance peaks as response peaks. Output impedance forms a voltage divider with the load impedance, and this is manifested in the response curve. Resistance in the circuit will exacerbate any peaks caused by standing waves or other internal reflections, since they create a corresponding impedance peak.

4. Drive signal. Different drive signals excite the device under test differently. In a hypothetical perfect device, this would not matter but in the real world, it does. See Keith Larson's discussion about measurement signal types. Also note that clipping can somtimes make a response chart unusually flat. Square waves generate several frequencies, so dips at specific frequencies will be missed because other frequencies are also present. This is not an issue if the measurement system uses bandpass/bandstop filters to reject noise.

5. Measurement method. Some systems measure amplitude response directly, usually with a stepped sine. Other systems measure time response directly, usually with a noise-like signal, such as a pseudo-random maximum-length sequence. The measurement system can translate frequency response to time response and vice-versa, but this is another hypothetical "perfect device" scenario.

In practice, I find some subtle differences in measurements made using various methods. Each method usually provides a lot of detail in some modes, and less in others. For example, swept/stepped sines usually provide very detailed response charts, provided the number of samples is high enough. And with bandpass/bandstop filters, they are pretty good at noise rejection too. But they are slow, and sometimes aren't as useful in the design phase, where time domain information is more helpful. On the other hand, broadband signals like MLS are great for design work because they are fast, and they're usually more accurate in the time domain. They obtain all information from a single quick burst, so are sometimes called real-time measurements. But they sometimes have limited resolution, so you can't see as much detail.

You can kind of lump 4 & 5 together, and just say "measurement system."

I have two different systems, one that I use for design work and another that I use for final test and verification. My development platform is WTPro, which includes a crossover design module that is extremely useful for me. I can design a circuit in Spice, and the system will simulate the transfer function. It's sort of like having an active DSP crossover that I can configure with a Spice model. I use it in the real-time mode, so it is very fast and quite accurate. But in this mode, the resolution isn't real high so I cannot see sharp notches. It's sort of like a natural smoothing mechanism, but it's really from resolution. The other platform I use is LMS, and it uses a stepped sine. I can set it up to give me as high resolution as I want, and I tend to set it for 100 points per octave. That is more than enough detail to see anything and everything.

When I start using a new device, I sweep it with LMS at high resolution to examine it closely in great detail. I am specifically looking for things like breakup in a cone driver or internal reflections in a horn. Those show up as spikes and notches. If I find too much of that, I abandon the device as being unacceptable. But if it measures well, then I move to the WTPro system to design and refine. After I am satisfied that the crossover is right, using a technique described in the "crossover optimization" thread, then I measure the completed system using LMS. If it is not perfect, I sometimes go back to WTPro and make changes, validating again later with another set of sweeps on LMS.

I have seen a lot of DIYers in the last few years using measurement systems that don't have a lot of resolution. That's fine, a big step up from having no measurement capability at all. Twenty years ago, all DIYers were blind, so even medium resolution systems are a huge step forward compared to that. Some even argue that the detail found in a high resolution chart is excessive, that the tiny details are inaudible. I've heard it said more than once that 1/6th octave resolution is plenty, because any detail finer than that is inaudible. I generally agree, but still prefer to reach a higher standard than that.

It's not just a matter of being a perfectionist. Sometimes lower-resolution charts miss detail that is audible. A sharp notch is probably inaudible, but a half-octave wide peak or dip is not. And I've seen a lot of these low and medium resolution systems resolve a device that has 3dB half-octave peaks and dips down to nearly a flat line. You probably can't hear a 10dB notch that's only 1/25th octave wide, but you definitely can hear a 3dB dip that's 1/2 octave wide. Peaks too, if it's more than about 3dB and more than about a quarter octave, you'll hear it. So if the measurement system misses that, you're blind. But I've seen a lot of measurement systems that miss even that level of detail.

That's why I use two different measurement systems and look at a device-under-test with several signal types. I put it through a suite of measurements on two different platforms using a variety of signal types. That gives me the best visibility and gives me a high degree of confidence that I do not miss any details. I realize most hobbyists cannot go to this level of detail, but that's what I feel I need to do in order to provide the highest quality products.

Subject: Re: An amazing listening session with the H290C
Posted by Ash R on Wed, 24 Apr 2013 13:02:06 GMT
View Forum Message <> Reply to Message

Regarding point 3, what is a current source and why is it important?

Subject: Re: An amazing listening session with the H290C
Posted by Wayne Parham on Wed, 24 Apr 2013 16:17:26 GMT
View Forum Message <> Reply to Message

There are a couple of mathematical abstractions in electronics, the voltage source and the current source. Basically, an ideal voltage source is one that has zero internal impedance and the ideal current source has infinite internal impedance. In practice, a voltage source has low internal impedance whereas a current source has relatively high internal impedance, compared to the load impedance.

Basically, you'll find that most modern amplifiers act as voltage sources. They have low output impedance - typically much less than an ohm - and provide good electrical damping for their loads. This makes them absorb back EMF from resonance pretty well, and impedance fluxations aren't terribly troublesome.

But add some resistance to the circuit and it begins to act like a current source. This resistance can be from a passive crossover, the connection cables or an output transformer, as in the case of tube amplifiers. Even the heating of the voice coil can create a similar effect, because even though it is a change in the load device, it acts much like a series resistance to the load.

optionally Rs and C1. Careful manipulation of these values provides just the right balance to lock in a specific transfer functon, even as parameters shift in the source or the load.

As an aside, you can use the constant current method to expose reflections and standing wave modes. The impedance spikes created by these reflections are sometimes damped well enough by a voltage source that they aren't immediately obvious. That doesn't mean they won't show up with a vengeance if used on a tube amp with low damping, or even because of parameter shifts, like what happens at high power levels.

So it is useful to examine the impedance chart for evidence of standing wave modes and reflections. They are sometimes small blips in the impedance chart, but when amplitude response is measured using a current source, these small blips will sometimes transform into surprisingly large ripple that isn't there on a voltage source. This is usually an indication of internal reflections, which are responsible for the nasal "horn honk" sound of some horns and the "spitty" or "splashy" sound of others. The nasal quality is usually from standing waves at the low end of the range, and the spitty/splashy sound is from reflections at higher frequency.

That's why it was so important to me to optimize the H290C to avoid internal reflections. Its oblate spheroidal flare provides a nice translation from planar wave to spherical section, and its depth/area ratio provides the right beamwidth with smooth response through the passband.

Subject: Re: An amazing listening session with the H290C
Posted by Bill Epstein on Thu, 25 Apr 2013 20:05:49 GMT
View Forum Message <> Reply to Message

Speaking of Tube Amps, last night I finally got around to installing the Hammond cover on my Single-ended Pentode amp so the Grandkid can safely listen with me.

Then I realised the power switch was somewhat less than ideally positioned

So I replaced it with the 45 Amp.

With the H290C, the 1.8 Watt 45s are easily 2dB louder and the imaging, especially on full orchestral, is improved. In fact, I seldom listen to orchestral music when the 45 Amp is in use because it can't handle the power of the orchestra. Last night, however, I listened to and enjoyed Brahms Symphony #1, as big as it gets.

Yeah, there's a touch of added brightness with the Cap in C1 and a few recordings could do without, but overall, perhaps because I can't hear highs at my age, anyway, it's just about perfect.

File Attachments

1) IMG_2404_1.JPG, downloaded 2477 times
2) IMG_3044_1.JPG, downloaded 2399 times
3) IMG_3028_1.JPG, downloaded 2351 times

Subject: Re: An amazing listening session with the H290C
Posted by Wayne Parham on Thu, 25 Apr 2013 20:55:12 GMT
View Forum Message <> Reply to Message

I've got an idea for a way you can flip that switch through the cover remotely. I can't take credit though, it's Rube Goldberg's idea, actually.

File Attachments

1) Rube_Goldberg_Remote.jpg, downloaded 2589 times