Subject: Helper Woofer Location
Posted by skywave-rider on Mon, 24 Oct 2011 19:40:16 GMT
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Wayne,

I am experimenting with building a 2.5 way speaker and I want to use your concepts relating to bass sources originating from different locations:
Speaker placement and wavefront launchMy cabinet will be 36" H x 9" W x 12" D. So I will have a lot of space to place the .5 woofer down the baffle. How would you determine the woofers' center to center distance? Guessing: Use ¼ wavelength at the .5 first order filter frequency. Is this a good rule of thumb? That's 17" at 150Hz and is perfect for the cabinet.

I say quarter wavelength because that would allow phase coherence above and below the .5 frequency. Am I looking at this correctly?
My LF drivers are 5.25" and the cabinet volume is 1.8 cu ft.

Is it more complicated than that because of the main woofer's position on the baffle? The main woofer's center will be about 12" down from the top of the baffle.

Subject: Re: Helper Woofer Location
Posted by Wayne Parham on Mon, 24 Oct 2011 22:36:19 GMT
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The best approach for the helper woofer is to locate it physically between the main midwoofer and the nearest room boundaries. So you might want to put the helper woofer on the back, near the bottom. I sometimes call this a "flanking sub" approach, because I usually do it with a separate woofer in its own cabinet.

You aren't looking for phase coherence, actually just the opposite. We're looking for phase difference. If the mains were coherent with reflections off the walls, ceiling and floor, we wouldn't need flanking subs. But they're not, and the interference that results creates distinct peaks and dips in various places throughout the room, especially at low and low/mid frequencies in the modal range. So we have to abandon the idea of coherent summation, and go for the nest best thing, which is dense interference. It makes the modal range act a little more like the reverberant field, statistically averaged in a sort of homogenous sound distribution throughout the room.

What you really want is for the helper woofer to be in between the main speaker and the floor, and also between the main speaker and the wall behind it. That way, self-interference from those two boundaries is mitigated, as are the higher frequency vertical modes that usually manifest in this range. It doesn't need to be run any higher than the Schroeder frequency, which is around 200Hz. Drive it with a low-passed version of the same signal sent to the main speaker it is flanking.

The way it works truly is by filling in the holes caused by self-interference. At some places in the

room, direct sound from the main speaker and reflection from the walls causes a cancellation notch. Said another way, at some frequencies, direct sound from the main speaker and reflection from the walls causes a cancellation notch at the listening position. But by placing a helper woofer or "flanking sub" in a different position in 3D space, the self-interference notches for the helper woofer will be at a different frequency. Where one sound source is cancelled, the other is not. The end result is response ripple is reduced by as much as 10dB. What may have been a 15dB-20dB hole without flanking subs becomes a much smaller 6db hole when flanking subs are used.

The most common way to implement flanking subs is with mains on stands, and flanking subs on the ground right beside them. The mains in the recommended crossed-axes position will naturally be two to three feet from the wall behind them and the stands typically bring midwoofer height around two feet off the floor. Flanking subs would then be placed beside, below and behind the mains, by being on the ground, and pushed back to the wall.

I find subs being outside the mains usually works best in small rooms, but having them inside, between the mains is better in larger rooms. A good rule of thumb is if the distance between left and right speakers is greater than the distance between the mains to the ipsilateral (closest side) walls, bring the flanking subs inboard. If not, leave them outboard.

The best approaches seem to be where the flanking woofer is run to somewhere between 150Hz and 250Hz, with a gentle first or second-order slope. Sometimes flaking subs work best with low-pass set a little lower, like around 100Hz, which then still blends into the mid-100s or so. Helper woofers placed closer to the mains - such as is often the case in 2.5-way speakers - can generally be run higher without localization problems.

Flanking subs do not get a summed signal - They get the same signal as the main speaker they are flanking, with a low-pass filter applied. They're stereo subs. That's one of the key distinctions between flanking subs and more distant subs in a multisub configuration. Flanking subs are closer than the more distant subs, and they are sent a low-passed copy of the same signal as the mains they're flanking. Distant multisubs get a summed signal, usually low-passed at a fairly low frequency around 50Hz to 60Hz.

I like flanking woofers to be at least a couple feet away, but not more than about four feet away. More distant subs can be used to smooth lower bass modes. Flanking subs are specifically there to help the upper bass and lower midrange where distant sound sources would become localizable. Above the Schroeder frequency, the flanking sub is rolled off, so the mains become a point source. But in the modal region, acoustically distant spacing between sources ensures that where one source suffers a self-interference notch, the other source fills it in.

The goal is for the speaker to act as a point source above the Schroeder frequency, which requires spacing between sources to be acoustically close. But below the Schroeder frequency, we want dense interference, which requires that the sources be acoustically distant. The tricky part is the transition.

I find that a gentle slope works best, gradually rolling off the helping woofer below around 200Hz.

It's a balancing act, because more distance allows modal smoothing to work at lower frequencies, but it also prevents this technique from being usable up high. The further apart the sound sources are, the easier it is to localize the flanking sub, so the further away it is, the lower the frequency limit where it can be used.
Room modes, multisubs and flanking subs

Subject: Re: Helper Woofer Location
Posted by skywave-rider on Tue, 25 Oct 2011 01:48:42 GMT
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Thank you, Wayne.

I guess I couldn't get away from the concept of reinforcing the LF response and maximizing that. Thank you for reminding me of the reason why I want to do this and setting me straight. :)

Modelling the 2.5 with woofer on the back might be a challenge. I suppose I will model with both woofers on the front, but place the .5 on the back. I'll let you know if I get anywhere.

Subject: Re: Helper Woofer Location
Posted by Wayne Parham on Tue, 25 Oct 2011 02:21:42 GMT
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Modeling won't show what we're trying to accomplish unless you do a room simulation. Most software I know of simulates a speaker in anechoic space or some simple radiating angle (e.g. halfspace). Room simulation software tends to see the source as a simplified radiator. I don't know of any software that does both at the same time.

The flanking sub approach is a room mode thing, and takes into account the difference between the modal range and the statistical range. It is something you can easily measure, but it isn't something that your typical crossover modeling software is going to show.

second woofer might be used in a 2.5-way configuration to help give some extra power where the response started to sag because of the baffle directivity transition. In a sense, the second woofer in a close-spaced 2.5-way is a baffle step compensation device.

Indoors, everything changes. You no longer want to increase point source energy in the modal region. All this does is make the modes stronger. Where there are nulls, no amount of power thrown at them will make the SPL greater. No equalization helps, because the nulls are a cancellation effect. More power in just makes more power to cancel out. All it does is to make the peaks between the nulls louder. So baffle step compensation is exactly the wrong thing to do, at least in speakers this size.

Likewise, you don't want to increase bass output in a point source by adding closely spaced woofers. That's why I propose what might be called a remotely-spaced 2.5-way speaker, which uses a helper woofer like a flanking sub. It smoothes higher frequency room modes, much like the multisub approach smoothes the lower bass. The helper woofer smoothes midbass and lower midrange, because it is set between the midwoofer and the closest boundaries, filling in the self-interference holes.

Again, the more oft-seen closely-spaced 2.5-way speaker would be appropriate in an anechoic environment, it's what you want for a speaker that will be used outdoors or in a very large room. But indoors, you really need to spread the sound sources around. The only way to smooth the peaks and valleys from room modes and self-interference is to increase the number of modes. You have to increase the numbers of sound sources, to fill in the holes with dense interference.

If you're planning to use this speaker for home hifi or home theater, don't waste that second woofer by putting it on the same front baffle. Put it a little further away. You can put the midwoofer and tweeter up high in front and put the helper woofer low in back. Or you can make a separate box to put the second woofer in, so you can place it a couple feet away in all three dimensions.

Try it both ways and measure the difference. Make one speaker a traditional close-spaced 2.5-way and make the other using two separate boxes, a main speaker on a stand and a flanking sub. You'll be amazed at how much smoother you can make the 80-200Hz range using flanking subs. You'll see about a 10dB improvement in the response fluctuation in that range. It will go from having a 15dB-20dB hole somewhere between 100Hz and 200Hz to having about 6dB ripple. Night and day better, and right in the fundamental range of piano, vocals, cello and many other instruments.

Subject: Re: Helper Woofer Location
Posted by skywave-rider on Tue, 25 Oct 2011 04:45:18 GMT
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Thank you again, Wayne. I now see that placing the helper lower on the baffle won't have the effect I thought it would. I am now considering either placing the .5 low on the back as you suggested or low and to the rear on a side panel. However I am also thinking about scrapping the entire .5 concept and just using flanking subs.

Subject: Re: Helper Woofer Baffle Location
Posted by skywave-rider on Tue, 25 Oct 2011 05:05:22 GMT
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Excellent post:
Baffle step compensation

Subject: Re: Helper Woofer Location
Posted by Wayne Parham on Tue, 25 Oct 2011 21:33:30 GMT
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I like the flanking sub approach because it is so flexible. If you wanted to use your speakers

passbands, you can always sit the mains on top of the subs for tight coupling. That's a typical prosound arrangement, with standard crossover techniques. But if you are using the speakers indoors, having separate subs allows you to position them as flanking subs between the mains and closest boundaries, or even position them as more distant multisubs, wherever they work best.

Subject: Re: Helper Woofer Location
Posted by Wayne Parham on Sun, 30 Dec 2012 17:07:37 GMT
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A little more discussion on the helper woofer / flanking sub approach:
Flanking Subs vs Helper Woofers

Subject: Re: Helper Woofer Location
Posted by dheflin44 on Sat, 22 Jun 2013 16:36:19 GMT
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Wayne Parham wrote on Mon, 24 October 2011 17:36I find subs being outside the mains usually works best in small rooms, but having them inside, between the mains is better in larger rooms. A good rule of thumb is if the distance between left and right speakers is greater than the distance between the mains to the ipsilateral (closest side) walls, bring the flanking subs inboard. If not, leave them outboard.
I have a 12' front wall with an 8' projector screen. The subs are short enough to go under the screen, but once my 4PIs are done they'll have to go next to the side walls (within a couple inches after toeing in 45deg). Is this recommendation meant to keep the mains off the side walls, or is it to keep the subs closer to the corner? Also is it a bad idea to place the 4PIs symmetrically in the corners? I can pull them away from the front wall a couple feet as needed.

Thanks,
Darrell

Subject: Re: Helper Woofer Location
Posted by Wayne Parham on Sat, 22 Jun 2013 16:55:53 GMT
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They are designed for corner placement, keeping the sound source acoustically close to the apex of the corner. That removes the need for flanking subs because there is no self-interference from nearest boundary reflections.

There is no way to place a matched-directivity two-way acoustically close to the corner unless it is mounted in a soffit. It's close enough at low frequencies, but by the lower midrange, it becomes acoustically distant, which is what causes the self-interference that flanking subs mitigate.

Soffit mounting always a great way to go, but most people don't have that luxury. So the next best thing is to use flanking subs, which at least smooth the self-interference notch(es) that result from nearest boundaries.

In your case, I think I would probably put the subs outboard, bringing the mains in a couple feet from the side walls. Push them back against the front wall, just close enough to allow the toe-in. Then push the subs back against the front wall and bring them in from the side wall a bit.

Try that and see how it sounds. You can always try the other way too, with mains outboard, but I think it will probably sound better with them inboard. But again, if you can do constant directivity cornerhorns, those are even better still.

Speaker placement and wavefront launch

Subject: Re: Helper Woofer Location
Posted by dheflin44 on Sat, 22 Jun 2013 17:23:28 GMT
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Wayne Parham wrote on Sat, 22 June 2013 11:55
Try that and see how it sounds. You can always try the other way too, with mains outboard, but I think it will probably sound better with them inboard. But again, if you can do constant directivity cornerhorns, those are even better still.
Unfortunately, I don't have anything to try it with yet. In fact I just sent you a PM for more parts. I'm just doing some planning and looking ahead.

I can't pull the 4PIs inboard at all without blocking the screen. I just wanted to see how big a deal it is to have the mains outbound, and also if they could be right in the corner (if needed they can come out into the room away from the front wall).

I have thought about the 7PIs, but at their normal distance from the corners they would also get in front of the screen. If I remove the doghouse in the back, how much closer to the corner can the 7PIs get without significantly affecting the sound?

-Darrell

Subject: Re: Helper Woofer Location
Posted by Wayne Parham on Sun, 23 Jun 2013 15:10:00 GMT
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As with all things, you can only make generalizations without testing. I found that doghouse shape empirically when I developed the first constant directivity cornerhorns. I also tested various compression ratios. The end result is the constant directivity cornerhorn as it exists today.

Subject: Re: Helper Woofer Location
Posted by dheflin44 on Sun, 23 Jun 2013 17:15:23 GMT
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Here's a sketch of the room and what I was planning initially.

Since the screen is 34" from the floor, I could make the 4PI stands only 6" high so they could slide under the screen. Do you think lowering the 4PIs would be a better compromise?

Thanks,
Darrell

File Attachments
1) harvest_point_study.jpg, downloaded 2840 times

Subject: Re: Helper Woofer Location
Posted by Wayne Parham on Sun, 23 Jun 2013 21:33:37 GMT
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It's hard to say if that will be too low or not. It always seems to me the most realistic impression is created when the speakers are generally the same height as the screen.

Sometimes, if the screen is a little above the listeners, the speakers don't need to be quite as high, but I don't like it when the sound comes from too close to the ground. It's not a problem for hifi, but for home theater, when trying to give the impression that the sound is coming from the images projected on the screen, they can't be too far apart.

Can you maybe set some speakers on makeshift stands (books, milk crates, etc.) and give it a try to see if the realism seems right?

I hate to sound like a broken record, but I'd put cornerhorns in that room. I'd do whatever other compromises I needed to do to make that happen. I don't know of any other configuration that

does what constant directivity cornerhorns do. You can come close with matched-dierctivity two-ways and flanking subs, but the clarity and imaging of midrange of constant directivity cornerhorns is stunning, and just can't be matched. Flanking subs mitigate a problem, but constant directivity cornerhorns completely eliminate that problem.

So I'd shrink the screen to fit the sound system. That's just me.