Subject: Driver Center to Center Spacing for Line Arrays
Posted by Jim Griffin on Fri, 06 Aug 2004 21:46:53 GMT
View Forum Message <> Reply to Message

I wanted to start a new thread on line array driver spacing versus adding on to DSM's posting on side by side placement. I made a challenge to Bill Fitzmaurice's comments on another forum. See this thread and page down to read all replies: http://www.diyaudio.com/forums/showthread.php?s=&threadid=38560Since I wrote my response on that thread I have condensed and summarized my thoughts on this driver to driver spacing. References to important JBL and L-acoustics papers are also available on the web as I discuss below:Driver to Driver Spacing in Line Arrays The driver to driver spacing concerns associated with line arrays composed of cone and dome drivers are well documented in the literature. The goal of the various researchers who have done this work is to create a coherent wavefront that radiates from the vertical axis in the array. Two companies present exceptional AES technical papers that document how they deal with this issue. Two references stand out in my search: 1. JBL Professional's line array technology reference (John Eargle, David Scheirman, and Mark Ureda paper entitled "JBL's Vertical Technology: Achieving Optimum Line Array Performance Through Predictive Analysis, Unique Acoustic Elements and a New Loudspeaker System" presented at the September 2000 Audio Engineering Society Convention) discusses line array spacing and basic line array performance based upon far field arguments. This paper is available on the web at:http://www.jblpro.com/vertec1/VerTec%20WP%202.3.pdf The JBL authors show the reduction of directivity when operation beyond one wavelength center-to-center spacing between elements in an array is attempted. They also illustrate how the off-axis vertical lobing (comb lines) increase as spacing exceeds one wavelength between acoustic centers. 2. The latest paper which documents more than 12 years of L-Acoustics' line array research is their "Wavefront Sculpture Technology" by Marcel Urban, Christian Heil, and Paul Bauman is in the Journal Audio Engineering Society, Vol. 51, No. 10, 2003 October and can be downloaded via:http://www.l-acoustics.com/pdfproda/wavefront.zip Much of this work details a novel Fresnel analysis technique that promotes understanding of their wavefront sculpture technology (WST) criteria. The WST criteria allow a discrete element line array to assimilate a continuous line source, i.e., radiate a constant phase front. Their conclusion is that the distance between acoustic centers of individual sources should be limited to less than a half wavelength. Other companies who produce line arrays for pro sound applications talk to how they attempt finesse the center-to-center spacing at higher frequencies via the usage of an acoustical waveguide (that is L-acoustics and several other companies solution) or circular throats to transform a set of compression drivers into a slot radiator. Several companies use flat diaphragm or ribbon radiators to address the high frequency issues associated with arrays of cone and dome drivers.My white paper on Near Field Line Array Loudspeakers (see the link below) details more specific tradeoffs on the spacing between drivers. My recommendation for driver spacing criterion is less than one wavelength (at the crossover frequency) distance between the woofers in a two-way array. Generally, cone or dome tweeters can not be located close enough to eliminate comb lines across the entire treble range. My tweeter line preference is to use either planar or ribbon drivers. These drivers typically do not create comb lines as their soundfields do not have sufficient overlap as frequency extends to 20 kHz. Jim
Near Field Line Array White Paper

Subject: Re: Driver Center to Center Spacing for Line Arrays
Posted by jdybnis on Sat, 07 Aug 2004 05:27:30 GMT
View Forum Message <> Reply to Message

Hi Jim,What about driver directivity? It seems that most drivers become directive when the wavelength becomes less than their diameter. Taken to the extreme, if a line of 8" woofers is playing above 10kHz I would not expect any comb filtering because the drivers would be beaming like spotlights. Hence in general I would expect that if the c-t-c spacing is greater than 1 wavelength but the inter-driver spacing is kept very small you would notice the sweet spot get smaller, and not necessarily any comb filtering.-Josh Dybnis

Subject: Re: Driver Center to Center Spacing for Line Arrays
Posted by Jim Griffin on Sat, 07 Aug 2004 11:31:09 GMT
View Forum Message <> Reply to Message

Josh,Excellent insight on vertical axis directivity. The JBL reference that I mentioned in my message shows how directivity suffers as spacing goes beyond one wavelength. In reality the reduction in sensitivity beyond one wavelength spacing is as bad or worst than the comb lines. Essentially, the wavefront starts to breakdown and becomes incoherent with resulant lobes or comb line responses off axis. While you still have an on-axis peak beyond one wavelength spacing, its level will be lower and you'll observe more power dispersed into these sidelobes and other off axis areas. Overall not a good situation. As you suggest with the beaming of the drivers beyond one wavelength spacing you'll narrow the sweet spot. At some point the sweet spot will become so diffuse that I suspect that you'll have a poor performing speaker. Jim

Subject: Re: Driver Center to Center Spacing for Line Arrays
Posted by jdybnis on Mon, 09 Aug 2004 04:46:39 GMT
View Forum Message <> Reply to Message

Jim,I've gone and read the JBL reference. I'm getting a bit lost in terminology. Am I using the the phrase correctly if when I say a speaker is directive I mean that the off-axis response is poor? The JBL paper seems to use it to mean the opposite. Also what do 'directivity factor' and DI mean? They are the labels on the vertical axis of graph 1B. Graph 4B seems to show horizontal lobing. Is this a separate effect than the vertical comb filtering you describe in your whitepaper? -Josh

Subject: Re: Driver Center to Center Spacing for Line Arrays
Posted by Jim Griffin on Tue, 10 Aug 2004 13:16:21 GMT
View Forum Message <> Reply to Message

Josh, Q is the directivity factor. It is the ratio of the sound power emitted by a non-directional (omnidirectional) point source to the sound emitted by a directional source. Directivity index is the logarithm (base 10) of Q and is expressed in dB.Line arrays gain thier advantage versus point source speakers by concentrating some of their radiated energy in the vertical axis. What this does is to make their vertical radiation greater so that the overall directivity increases. This is similar to horn loudspeakers which constrain their radiation (usually in both horizontal and vertical directions) to specific angles so that the sound produced is greater in one direction versus another. I'm like you--a little puzzled by the 4B figure in the JBL paper--but I think it shows the lobing due to the comb line effect.Jim

---

Subject: Re: Driver Center to Center Spacing for Line Arrays
Posted by jdybnis on Wed, 11 Aug 2004 19:00:44 GMT
View Forum Message <> Reply to Message

Thanks for the answers. This makes sense.-Josh
