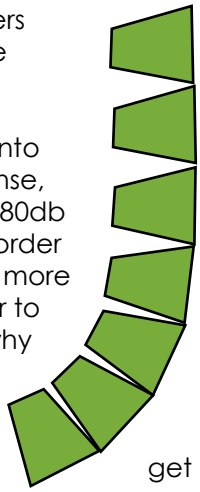
# Understanding Line Arrays

by Mark Hartshorn

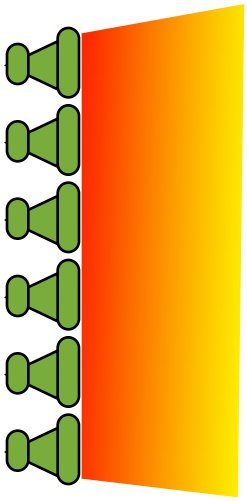
In recent years, speakers have seen a significant change in design with the use of "Vertical Line Array" systems. The theory of line array systems is not new at all. In fact, line arrays systems were seen a lot in the 70's with "column" design speakers. However, there were a number of issues that plagued column speakers and those systems are no longer used on a professional basis. However, with advanced speaker and driver design, along with improved high frequency horn design, line array systems have seen a major resurgence in the professional audio market.

**The Basics:**

So, what makes these systems work? The key to line array systems is how the drivers work together in multiple speaker configurations. The key elements of vertical line array benefits are long throw coverage and low frequency directionality.



**Long Throw Coverage:** The idea here is simple, if you have more drivers pointing into the same area, each of them running at the same volume and frequency response, then the volume for that area is louder. (Example: 1 speaker pointing at you is at 80db spl, add another speaker at the same volume, and now you are at 86db spl). In order to cover seating areas that are farther away from the speakers, you would point more speakers into that arof ea. As you have your speakers cover areas that are closer to the array, you would gradually have fewer speakers point into that area. This is why most vertical line arrays have a "J" type of look to them (Like the picture to the =8right). In the top of the array, you will have several speakers pointing into the seating area farthest away from the stage, then you would slowly add more and more angle between each speaker to shade the coverage as you get closer to the stage. Finally, you would probably end up with only 1 speaker covering the area closest to the stage.



**Low Frequency Directionality:** The concept here is a little more complex. One of the key parts of audio system design is to keep sound away from the areas you don't want it. For example, don't point your speakers into ceilings or walls. Advanced horn design has allowed high frequency control in speakers for quite some time. However, a horn design to control lower frequencies would be quite large and unusable from a touring or concert standpoint.

It turns out, that when you take multiple low frequency cone drivers, and array them together into a strait vertical line, where all of the drivers are an equal distance apart and operating at the same volume and frequency response, The combination of the array actually causes lower frequencies to show directionality in the vertical plane. As a result, putting all of your lower frequency drivers in a row gives you increased output of your array while keeping those lower frequencies off of the ceiling. The frequency range of this directionality is directly related to the vertical height of the line array, which is equivalent to the frequency wave length of the lowest frequency that exhibits directionality control.

**Speed of Sound:** Aprox. 1130ft per second in air (Rounded off).
**Wavelength:** 1130 ÷ frequency = wavelength (or 1130/Wave = Freq)

So, lets say you have 6 speakers in a strait line, and each of the speakers is 18 inches high. The total height of your array is 6 ft: ***1130 ÷ 6 = 188.3***

This shows that your array is directional down to about 188Hz. All frequencies below that will bounce around like they normally do coming from a single speaker.

**Other benefits:**
**Rigging:** Line arrays are much easier to rig. In fact, many arrays can be rigged using only one or two motors and 2 or 3 crew members. Also, manufacturers have gotten their act together about designing rigging systems. Often, a vertical line array can travel with almost all of the rigging attached to the speakers, with only a bumper bar and motor rigging to travel separately. Previous convention speaker arrays where much more complicated and had a lot more parts to deal with.
**Truck Packs:** You can usually get a better coverage of your seating area with fewer speakers in a line array as opposed to a conventional array. The advantage of long throw array design limits the need for a large number of delay lines. Also, your rigging requirements are less, and your cabling requirements are normally less. As a result, you carry fewer boxes on the truck, which can help you in a number of ways.

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**The Drawbacks:**
Okay, that's cool. So what are the problems with using a line array? Like all systems, the key to using a line array is using it correctly. There are drawbacks to this system which may or may not be a significant issue in your system design. Let's talk about some of those issues.

**Horizontal coverage:** As mentioned earlier, the vertical coverage of a vertical line array is normally well controlled and fairly even in a well design system. As a result, the horizontal coverage is largely ignored. As you move off axis of a vertical line array, the frequency response varies and is not totally even. High Frequency horn designs have to be built to have a real narrow vertical coverage (Normally 5º-10º), while also splaying out horizontally at a very wide angle (normally 90º-120º). This is very unnatural for the physics of sound waves, and results in variable coverage.

**Tall Arrays:** Getting even coverage to a seating area that is far away requires more speakers pointing into that area. As a result, the entire array can hang low and get into sight lines. Also, to really achieve even coverage, your array needs to be hung higher in the air than a conventional array, which requires the need to find available rigging points to allow for higher motor limits.

**Loss of Low Frequency Directionality in "J" Arrays:** So, as mentioned earlier, a strait line array allows you to get increased low frequency directionality. However, this only works for the drivers that are in a strait line. Of course, in order to get an even audience coverage , line array speakers are normally hung in a curved array, where the curve becomes more steep at the bottom. Once you start curving your array, you begin to loose the directionality benefits of your low frequency line array. So, when you are trying to figure out what frequency your directionality goes down to - now you have to consider only the speakers that are essentially in a strait line. once the angle between speakers is more than about 4º-5º, you will loose this effect. However, in a standard "J" array, you will still keep a significant amount of low frequency sound off of the ceiling, which is always a good practice.

Over all, Line Array systems offer significant benefits over convention multi-speaker systems for a large number of professional uses. However, this design is not a "one size fits all" system. There are other benefits and drawbacks not mentioned here. Also, having only a few boxes is not an array. 2 or 3 boxes in a row will not provide any line array benefit at all. There are also "Horizontal Line Arrays", which work the same way, but in the horizontal plane. These system are good in situations where you have a very wide coverage area, but with a minimum distance to the back row. This is very similar to most "conventional" multi-speaker designs.