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Subject: Re: Probable dumb question - Where's the midrange driver?

Posted by [Wayne Parham](#) on Wed, 09 May 2001 07:35:46 GMT

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That's a very good question. Thanks for asking, giving me the opportunity to explain. The three Pi and four Pi loudspeakers are what I call DI-matched two-ways. They have a high-efficiency midwoofer that operates through the midrange, into the overtone range before crossover to the tweeter. This allows vocals and instrument fundamentals to come from a single driver, with overtones and very high frequencies provided by the tweeter. I think it's a natural place to crossover. The name implies the philosophy, DI-matched meaning the directivity index is matched at the crossover point. The woofer is a round radiator and at higher frequencies, it begins to become directional. At low frequencies, the cone is small compared to wavelength but at high frequencies, the distance from edge to edge becomes closer to wavelength proportions. As the woofer enters this frequency range, its radiating angle begins to narrow into a cone shape. This is because an off-axis listener is closer to the near edge than the far edge, and where the path length difference is 180 degrees apart, a notch forms, marking the edge of the pattern. In a DI-matched speaker, this angle is matched to the horizontal pattern of the tweeter, so they both have approximately the same directivity at that point. I prefer to use tweeters with narrower vertical coverage than horizontal, usually something around 90x40 degrees. In this case, the directivity index of the tweeter is usually a little higher than the midwoofer at the crossover point, because its vertical directivity is narrower than the horizontal, making the combined DI figure slightly higher. But precise DI matching isn't important. What is important is that coverage is uniform along both horizontal and vertical axis, and that requires an asymmetrical pattern with DI approximately matched at crossover. The horizontal patterns overlap coherently, but the vertical patterns only do within a certain angle, depending on the distance between woofer and tweeter. Vertical stacking of the midwoofer and tweeter make nulls appear above and below the speaker in the crossover region. These nulls are closer together - at a narrower angle - than the nulls from the edge-to-edge path length difference from the midwoofer alone. The reason is the same, there are path length differences between the listener and the closest sound source and the furthest sound source. In the case of the vertically stacked woofer/tweeter pair, the distance from top of tweeter to bottom of woofer is greater than woofer edge to edge, so the null angle is smaller. This modifies the vertical radiating angle, narrowing it in the crossover region. That's why I like to use a tweeter with narrow vertical pattern, so it is nearly matched to the null angle imposed by vertical stacking of drivers. The overall effect of all this is you have a speaker that sounds very much the same at all angles within the tweeter's coverage pattern. Outside this pattern, sound falls off sharply as it enters into null areas. The net result is a uniform coverage, with spectral balance in the reverberant field. This sounds much more natural than a speaker that has less uniform off-axis coverage, even if its on-axis response is very good. That is because even though you may listen on-axis with the speakers pointed at you, the aggregate of all on and off-axis energy is what makes up the reverberant field, and that is responsible for much of what you hear.