HOME Theater

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Home Theater Acoustics

Volume Four

Ambiance speakers are readily becoming standards in home theater

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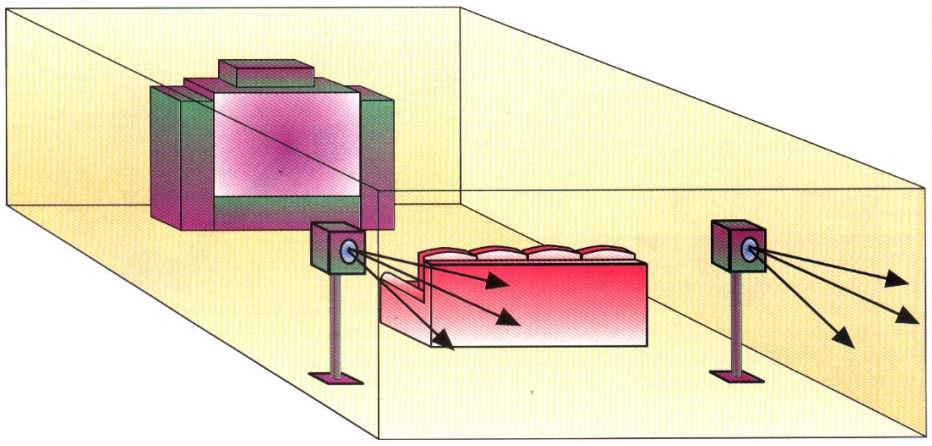
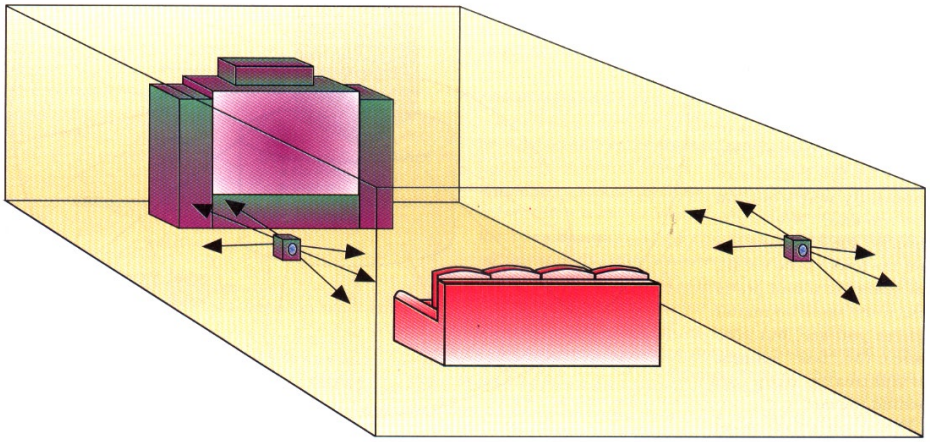
As we survey audio systems for home theater, a trend appears. We consistently find one or two subwoofers, two or three stage speakers, and two ambience speakers. In the last two sections, we studied the subwoofer as it fits into and plays the listening room. Here we will study ambience speakers, the kind that are becoming a standard for home theater.

The Dolby surround signal is a mono signal usually fed to two speakers located towards the back of the room. This signal is unique in audio because it is rolled off at 100 Hz. This doesn't mean that there should be no deep bass in the ambience effect. It does mean that the deep bass is generally understood to have no directionality. Our head is too small, our ears too close together, and our hearing too insensitive to be able to tell which direction low frequency sounds are coming from. Remember how no one worries where the subwoofer is placed, except for visual or room mode control? That's because we can't tell where the bass is really coming from. The way we "know" where bass comes from is by focusing on where



Ambience Speakers – Standard



Surround Speakers – Dipole

the upper partials of the bass sound are coming from. The Dolby surround signal contains the upper partials of the ambience bass, so we think the ambience bass is coming from the ambience speakers. But really, it's the subs and main speakers that get the signal and do the generating of the ambience deep bass.

There are two basic kinds of ambience speakers these days, although more may pop up as time goes on. The first, most basic type are simply small, book shelf type speakers on speaker stands or mounted ot the wall. The ambience signal can be beamed either: directly at you or away from.you/ bouncing around the room a bit before it hits you. If the speaker is aimed directly at you, you will hear it and know where it is. Our hearing is very sensitive to sounds beaming directly into one ear. After all, what do we do whet we can barely hear some sound? We turn our head to the side, so one of our ears can hear the sound more directly. For the ambience speaker setup, the orientation of the speaker is a matter of personal choice and the experiments should be made. Many people prefer not to hear the ambience signal directly and their ambience speakers are turned somewhat towards the wall and face either forwards or backwards.

The second type of ambience speaker is called a surround speaker and is recommended by the THX people. In this system, the choice about how we hear the ambience signal has been made for us. This speaker is mounted high on the side wall and set up to not beam any sound directly at the listener. These speakers are specified to be primarily dipole type speakers. This means that they play backwards and forwards equally strong, but not at all to their side, which is, of course, where the listener is located.

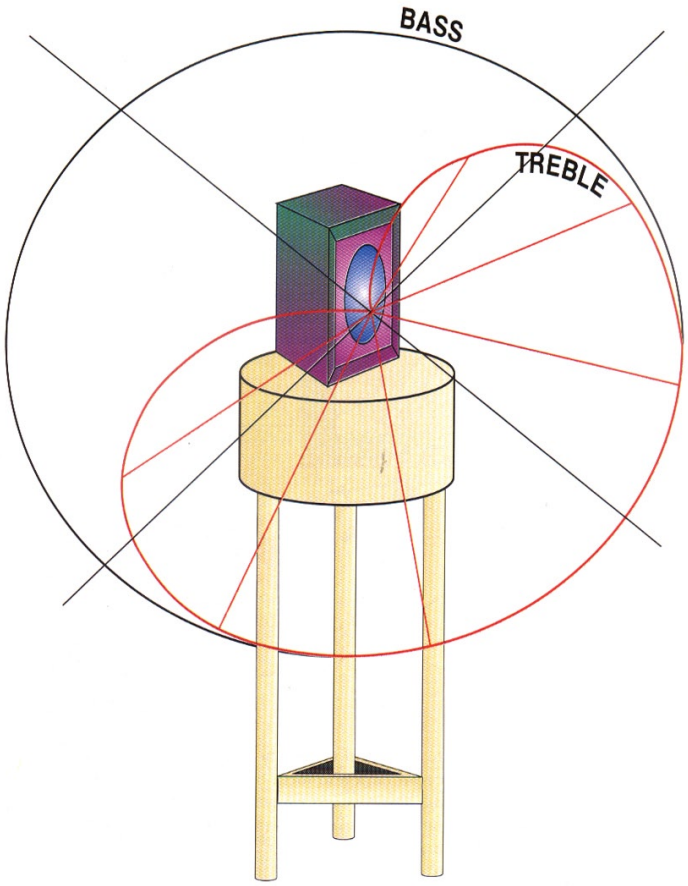
The dipole speaker familiar to us in hi-fi is usually a thin sheet of material that is forced back and forth by either magnetic or electric fields. The forward wave is exactly out of phase from the backwards wave. When the sheet moves forward, a positive pressure wave is sent forward while a negative pressure wave is sent backwards. Not so for most surround sound speakers. This type is often comprised of two dynamic speakers wired out of phase and playing back to back. There still is a positive wave sent out in one direction, while a negative wave is sent in the other, being equal in strength but opposite in phase. There are numerous dipole speakers and the goal here is not to propose or evaluate which might be better than the other, if such would even be possible. The goal here is to explore the effect on the sound of these speakers that is imposed by the room in which they are located.

The dipole type surround speaker is a strange kind of speaker to the world of audio and it will, without a doubt, undergo a number of transformations as it evolves into its mature form. To begin with, it is not a full range speaker because the surround channel is rolled off at 100 Hz. For the most part, these speakers nave been a small speaker cabinet with two speaker baffle boards, one set to face forward and the other to face backwards. Usually, we see each panel forward and the other facing backwards. Usually, we see each panel mounted with a single driver. Two-way speakers are also used, sometimes with the tweeter offset from the main driver, other times with coaxial drivers.

The intent of this style of speaker is to "play forwards and backwards" so as to illuminate first the room and not first the listener. This directional effect only works for a limited frequency range of the speaker. Small-sized drivers are directional for upper, mid, and high frequency ranges, but become omni-directional for the lower ranges. This directionality effect occurs at a predictable frequency based on the size of the drivers, as well as the cabinet in which they are mounted.

A good demonstration on the directionality of a speaker can be achieved by setting a small loudspeaker outside of the house on a table that is placed in the middle of the open yard. Then, while keeping some fixed distance away, walk all the way around the speaker while it is playing some tune with which you are familiar. You will hear the full range of sounds of your speaker when you are in front of the speaker, but as you move to the sides, and especially when behind the speaker, the highs drop off substantially, but not the lows. Male vocals, for example, sound pretty much the same no matter where you are, but sibilance, the "tsss" sounds, dramatically drop off behind the box.

If you get an identical second speaker, wire them up in phase and place them back to back. You'll hear bass range

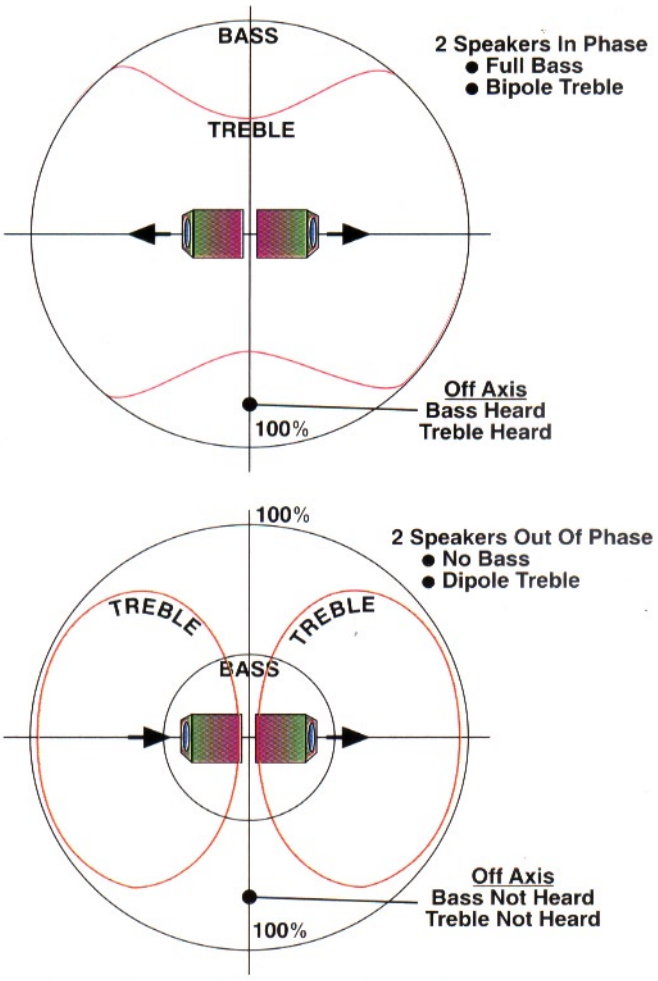


Bass/Treble Directionality

everywhere and the sibilance will be heard in two beams, One forward and the other opposite. Listening directly off to the side of the speaker pair, you'll hear the midrange and bass. Now reverse the phase of the two speakers and listen. All of the bass drops out, yet the two mid/high back to back beams remain. To the side, there is a strange drop in all sound. So it is with the dipole speaker. The dipole effect is limited to the upper ranges of the speaker because the bass shorts out, acoustically speaking. At some low frequency, the dipole speaker simply sloshes air back and forth around the edges of the speaker and makes no more sound. This is nc different than listening to a bare speaker and then mounting it onto a piece of plywood. We increase the distance between the front of the driver and the back and, in doing so, give the speaker more range in the bottom end.

Because the surround dipole speakers are fairly small, they short out at fairly high frequency, around 400 Hz. And, so, there must be another system in place to generate sounds below this natural dipole cutoff. There are a number of ways to accomplish this. The most straightforward way is to use a single lower frequency driver reversed, large-sized, and directional midrange drivers. Offset or coaxial tweeters will accompany these large midrange drivers to get full high frequency range. The main thing to keep in mind during the evolution of this style speaker is that the orientation of the low frequency drivers is irrelevant as to the directionality of the lower registers. Omni is omni and it doesn't matter which direction the midbass speaker(s) points.

There seems to be only a couple of rules to follow when placing the surround dipole speakers. Mainly, they have



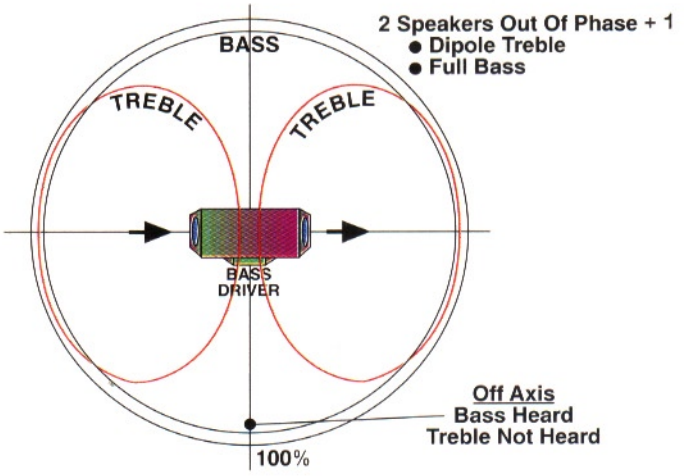
In And Out Of Phase Directionality

to be placed high on the side walls, directly to either side of the listener position. They can be positioned in front or behind the listener somewhat, but must be angled so that the side of the speaker points to the listener. Above all, never place them in bookshelves no matter how convenient it may seem. The honky, tonal resonances this setup produces will be almost unbearable, not to mention that the walls of the bookshelf will catch the ambience signal before it gets to the room. These surround speakers are to fire along the side wall towards the front and back walls. Next, there are three factors to be considered in the placement of ambience speakers -- resonance, self-canceling, and flutter.

Whenever a speaker is placed in a room, it needs to be positioned so as to minimally stimulate room induced coloration effects. This is especially true for ambience speakers because their effects are in direct competition with the room's natural ambience for the listener's attention. If the

ambience speakers are located improperly, they will strongly stimulate the local room effects and their capability of generating the desired audio track ambience will be reduced by the sound masking effects of the room's acoustics.

We know the ambience speaker is to be located high on the side wall by the listener. Beyond that, we seem to be left to our own resources. The lower frequency play of the speaker can be used to determine the most neutral vertical location

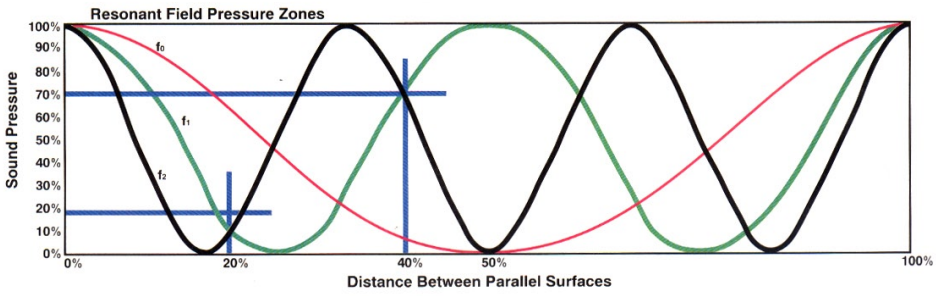


Surround Sound Directionality

on the side wall. The high frequency characteristics of the speaker can be used to determine the most neutral front-to-back position for the speaker. In the following sections, we go over the details that determine the most neutral position for the ambience speaker.

ANTI-RESONANCE AND SELF-CANCELING

In the previous chapter, we studied how to determine the most neutral position for the placement of subwoofers in the listening room. Two factors came up to impact the coloration of the sound quality. The first and most familiar was room resonances. We determined that placing the speaker so as to least stimulate the room resonances would be most appropriate. In addition, there is the complication due to placing a speaker near a wall, floor, or corner - a self-canceling effect. The nearby reflection actually weakens the strength of the speaker at a certain frequency.



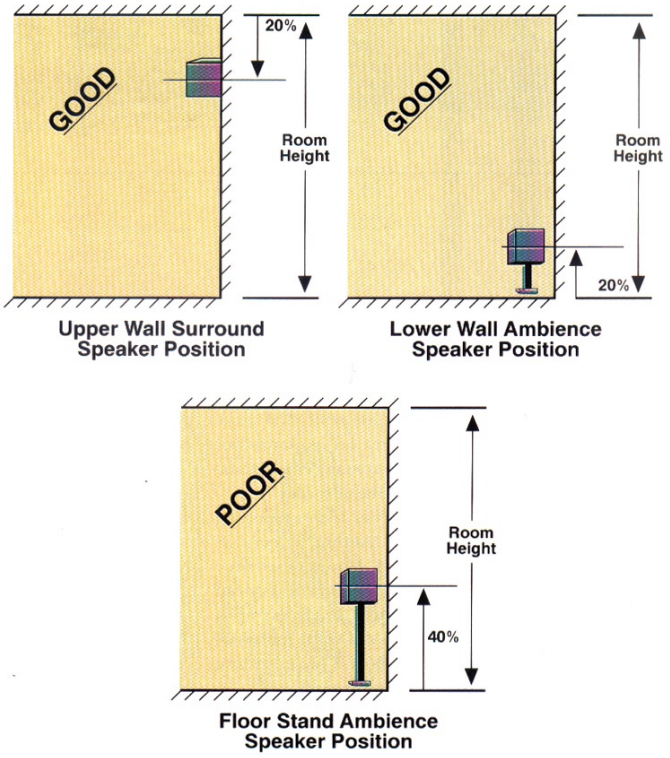
2nd and 3rd Resonance Minimum Position

These lessons also apply to the ambience speaker positioning. The ambience speaker is essentially a single, mid-bass driver with two reversed phase, mid/hi drivers, back-to-back. The vertical position of the speaker on the side wall is determined by the speaker's low frequency coupling to the floor/ceiling parallel surface system. We saw that when the frequency range of the speaker spans many resonances, the best location for the speaker is at the 25 percent mark from one end. However, for the ambience speaker, it is rolled off at least 100 Hz or higher. This means the first floor to ceiling resonance, typically at about 70 Hz for an eight-foot room height, cannot be stimulated. By studying the pressure distribution for the first three resonances and ignoring the first one, we see that the minimum position for stimulation of the second and third resonances lies 20 percent from one end of the dimension. This means the best, anti-resonant location will be a distance down from the ceiling that measures about 20 percent of eight feet or 1.6 feet (19 1/4 inches) down from the ceiling or up from the floor.

For the ambience or surround speakers that are mounted high up the side walls, the 20 percent down position is easy. However, for those ambience speakers that are on speaker stands, putting the speaker 19 inches off the floor is not a normal thing to do. Most speaker stands are set up to position the speaker about ear height, 42 inches off the floor. There is another position, not nearly as good as the 20 percent position, but at least it is a relatively minimal position. This is at the 40 percent point, where the first and second harmonic curves cross just below the 50 percent point. The traditional speaker stand positioning of 42 inches places the speaker at the 44 percent height point for an eight-foot high room. It is not easy to change the height of a metal or even a wooden speaker stand, nonetheless ... we are at this time concerning ourselves with good acoustics, not convenience.

Every time the speaker is located near a reflecting surface, the problem of self-canceling comes up. For a speaker mounted 20 percent down from the ceiling, the self-canceling frequency occurs at a wavelength that equals four times that distance or 80 percent of the room height. The wavelength that goes with an eight-foot high room will be about 6.4 feet, which corresponds to 1130/6.4 or 177 Hz. By the way, there will be reinforcement at twice that self-cancel frequency at 354 Hz and then a cancel at 530 Hz, and so on. Every 177 Hz there is a self-induced effect that alternates between cancel and boost. This is on the order of a four to six dB magnitude and stops only when the speaker becomes so directional that it doesn't illuminate the reflecting surface, typically about 600 to 700 Hz.

It is very easy to remedy this self-canceling problem. Simply, bass trap the bounce back point. But not just any bass trap will do. The low frequency cut off for the bass trap should be set about a half octave below the lowest frequency that needs to be trapped. For 177 Hz, this is figured as follows: A full octave below 177 is 88 Hz, so a half octave below is half of 88 or 44 Hz. The half octave below 177 Hz is 177-44 or 133 Hz. Now that you know all about it, the simple formula is that the lower half octave point is 75 percent of the given frequency.

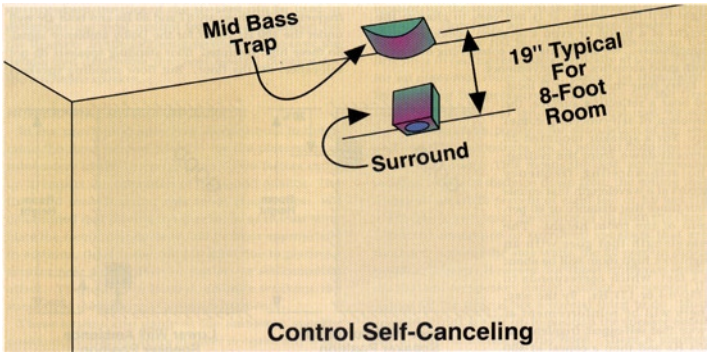


Anti-Resonances – Best Positions

The floor standing ambience speakers seem to luck out as far as self-canceling effects go. Their drivers will be 39 to 42 inches off the floor and self-cancel at four times those distances, for the 15- and 14-foot wavelengths. The frequencies for these are 87 and 80 Hz and both are well under the 100 Hz cutoff for the Dolby ambience signal. So these high mounted, floor standing speakers do not self-cancel off the floor. But floor standing speakers tend to be set up away from the wall. While the floor bounce may be too far to self-cancel, the nearby wall bounce can be a problem. We know the omni speaker is rolled off at about 400 Hz. The 1/4 wavelength dimension for this is 8 1/2 inches, which becomes the maximum distance this driver should be away from the wall and not self- cancel from the wall bounce.

Why, one might ask, should we be careful of the range of the bass trap we use? Also, who needs a "bass trap" anyway? Don't acoustical foam or wall panel type products absorb sound and at a lot less cost? The questions are proper to ask and deserve an explanation. They all involve the balancing of frequency characteristics, those of the speaker to those of the absorber.

A speaker loves to be near a corner when reaching for its lowest registers. The "horn loading" effect due to placing a speaker near a wall, floor, or corner increases the efficiency of the speaker in the bottom end, more bass power at no extra cost. If a bass trap is placed in the corner, we usually do not want it absorbing the deep bass. We want the opposite, horn loading to reinforce the deep bass. For this reason, we need the bass trap to roll off its absorption in the range where the speaker output is also rolling off and the benefits of horn loading are being called into action. For small, full range boxes, this 3 dB down point (50 percent power) can typically be about 60 Hz. But as mentioned above for the home theater ambience speakers, the roll off is set at about 100 Hz or more.



Now we'll move onto acoustical foam and wall panels. These fairly common acoustical products are good only for the midrange and high frequency ranges. This range includes only the top three octaves of the piano keyboard and does not include anything in the lower 4 1/2 octaves of the keyboard. Only bass traps can cover this lower range of sounds. The middle of the keyboard is C4 at 256 Hz. In our example, we needed the absorption half power point to be at 133 Hz and that's almost one full octave below middle C. It also is two full octaves below the roll off point of commodity foam and wall panels. Bass traps are the only absorptive devices that can correct acoustical problems.in the lower 60 percent of the piano keyboard.

CONCLUSION

Ambience speakers, like all others, engage the room acoustics. Because of their limited bandwidth, they do not couple to the lower resonances of the room. That gives us the most neutral, anti-resonant position yet for the speaker position, 20 percent off the floor or down from the ceiling. Something new has been added to help smooth out the acoustic space for the speaker - the bass trap - the self-canceling bounce back point. The best ambience sound is colorless, except for the ever changing signatures in the ambience track.