PRINCIPLES AND TECHNIQUES OF SPEAKER PLACEMENT

SONICS
by Joachim Gerhard

With most good quality music systems the room becomes the limiting factor in sonic performance. There have been many articles and theories presented on speaker-room interface and also about the damping of critical room resonances. Constructing speakers with room interface in mind can result in speakers that only work in one type of room, or in one position in a room. Efforts to damp out room resonances to get a flat amplitude response are usually costly and can result in a lifeless sound. The solution presented here is aimed at limiting the interference of the room, with speaker placement and listening position, through the application of psychoacoustics and physics. This method can give superb results through experimentation without the use of special room treatment. However, it may be possible to get even better results with carefully used room treatment.

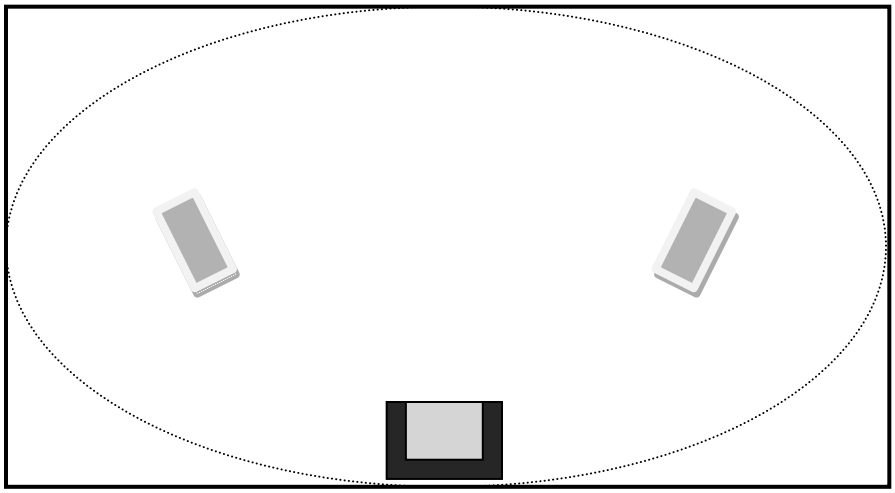
The way we locate sonic events in space is by the brain measuring the time delay of the sound between the two ears. If there is no delay the sound emanates from directly in front of us, if it reaches the right ear first it is to the right, etc. The brain determines location in the first 800μs of the transient because this is the maximum time delay possible due to the distance between the left and right ear. It is after this initial recognition of location that the perception of tonality starts. This has been proven in scientific studies and is believed to be a critical part of our survival historically. In other words, we first locate the source of a sound, a potential danger for example, and then try to identify what made the sound.

So, the first step to getting a good stereo soundstage is to eliminate early reflections of the leading transient as much as possible. In practice, to have the sound from the speakers arrive at your ears before any reflections. This prevents any confusion as to where the sound is coming from. A psychoacoustic phenomenon called the Haas effect, states that the brain prioritizes the first sound wave to avoid confusion. Which is the same as saying the brain ignores reflections if they are not too loud. Also, if the speakers measure flat under anechoic conditions, the brain will register flat response when it hears the first transient without reflections. So, even if tests from the listening position indicate severe deviations in frequency response due to reflections, the brain will ignore this and perceive flat response.

To illustrate a set-up using these principles, let’s imagine a well-proportioned room that is dedicated to listening. The ideal location for the speakers is at the two center points

of an ellipsoid touching the walls of the room. The best listening position is 1 to 3 ft. from the rear wall. Make sure your system is wired in correct phase! The advantage of this placement is that it allows the maximum possible speaker separation for the widest desirable soundstage, and it places the speakers away from all walls to maximize reflection delay.

In this position the sound from the speakers reaches the ears before any reflections coming from the sidewalls, resulting in a better soundstage and an unaltered perception of the speakers' tonal balance. Here is the basic formula to calculate reflection delay. The distance from the speaker directly to the ear should be at least 5 ft. less than the distance from the speaker, to a reflective surface, to the ear. For example, speaker to ear = 6 ft. Speaker to wall = 5 ft., and wall to ear = 8 ft. for a total distance of 13 ft. calculating 13 ft for reflection – 6 ft from source = 7 ft., so this will work. The technical reason for the 5ft. difference is that if the secondary sound arrives at least 5 milliseconds or later after the primary sound, the brain recognizes it is not the source. It requires sound 5 milliseconds to travel 5 ft.



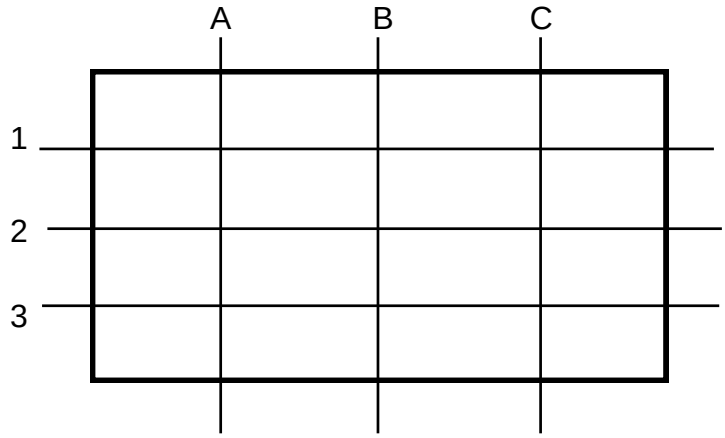
There are two reasons for sitting close to the rear wall. First, at the room boundaries (walls) the sound pressure is high and the velocity is low. Sitting in the maximum pressure area gives the best perception of deep bass. Secondly, the reflections are shorter than the circumference of the head, so the brain cannot measure the time delay between the ears, and therefore cannot localize the source of sound. When the brain cannot localize reflections it ignores them.

Here is a simple example of the brain ignoring unwanted or unessential information. Imagine being in a noisy public place and conversing with the person next to you. Even though a recording made where you are standing would sound like random noise, you can isolate the conversation. If you hear your name spoken several feet away, you can change your focus, and "listen in" on the other conversation. Our brains do this

automatically all the time, for example, to filter out a distracting natural resonance of a room to facilitate speech, or to identify potential dangers. So, in this listening position your brain will "listen in" to the primary source and ignore the reflections.

To sum up, it is usually best to locate the listening position so the first information to arrive at the ears is from the speaker. The secondary reflections should arrive much later and at a much lower volume. Place the listening chair near the rear wall, because the distance (1 to 3 ft.) creates too short a time delay for the brain to locate the source of the reflection. Finally, it places you at the room boundary where the perception of bass is greatest.

Let's expand on the information regarding bass reinforcement. This is a method we call room mapping. The underlying principle of this technique uses principles of wave phenomenon. Since it is uncommon to have a dedicated listening room, and one of ideal proportions at that, here is how to locate the speakers according to room dimensions. Accurately measure the room and draw a simple floor plan. Divide the room into quarters. At even points in the room, bass frequencies are reinforced.

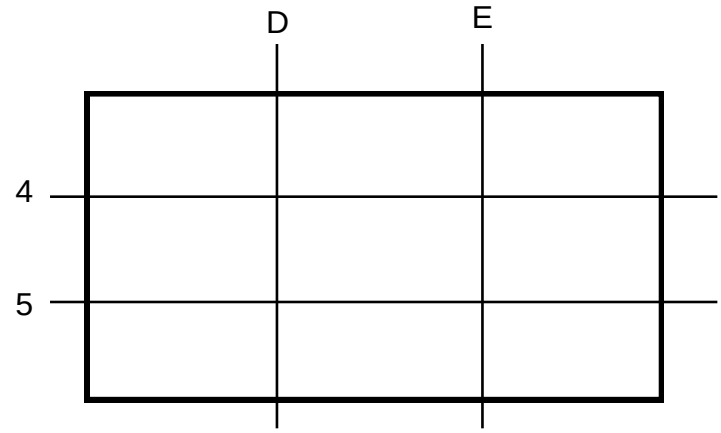


Referring to the above example, the cross points 2A and 2C are the ideal starting position for speaker placement. Place the listening chair at B less than 3 feet from the wall.

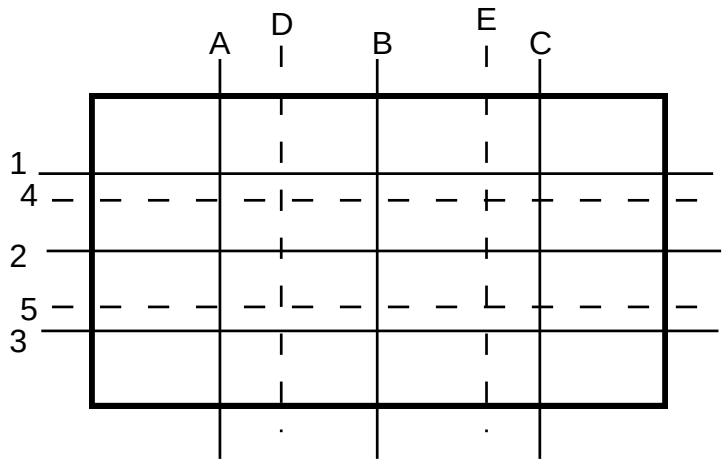
If you want to set the speakers on the short wall in a more traditional arrangement, you can get good results for bass reinforcement by placing the listening chair against the wall at line 2 and placing the speakers at B1 and B3. The next best speaker location would be A1 and A3 or C1 and C3.

You can also place the listening chair at 2B and the speakers at A1 and A3 or C1 and C3. Or place the chair at 2A and the speakers at C1 and C3. The disadvantage of these locations is narrow speaker placement and increased side wall reflection. The final arrangement is usually determined by room size and furniture layout. However, by placing the speakers and chair at an even division point of the room, you will get natural bass reinforcement.

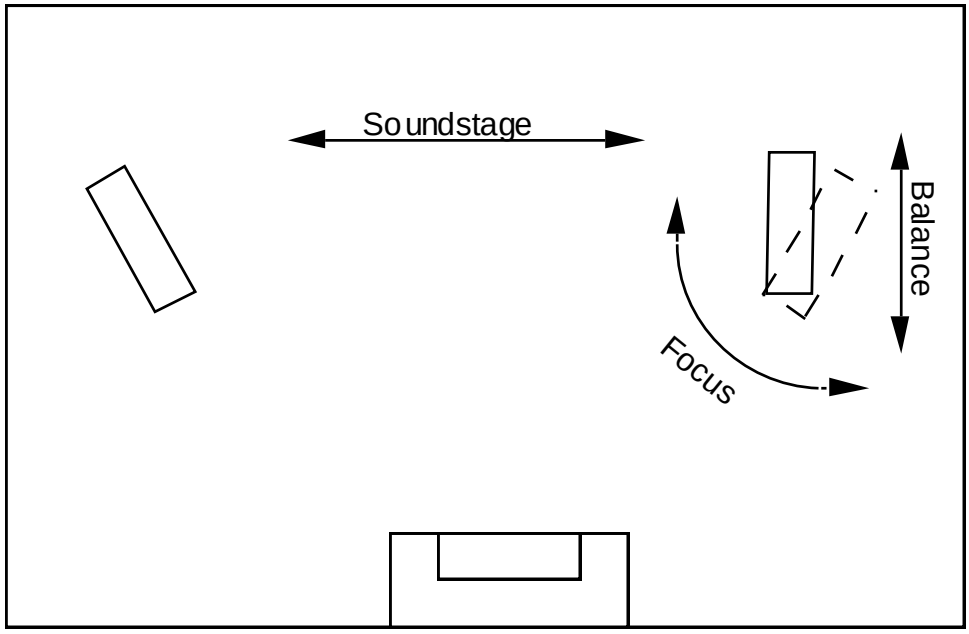
A method of tuning the bass and mid-bass is by using the same principle to cancel, rather than reinforce, low frequencies. To do this you move the speakers toward odd divisions of the room. This illustration is another drawing of the above room divided into odd increments. The cross points are the locations with the least bass reinforcement.



It's important to remember is that the room can be divided into far more than just quarters or thirds. At even divisions the bass is reinforced and at odd divisions the bass is canceled. By overlaying these grids you can see that small movements can have a large effect on the sound.



For tuning, the general tendency is for sideways movements to effect the mid-bass and forward and backward movements to affect lower bass.



After determining the general placement for deep bass with the above room mapping technique, the next step is to determine the distance between speakers. Using a recording with strong center information, a vocal or mono recording works well, listen to the center-fill with the speakers pointed slightly behind the listeners head. Move them apart about 6 inches and listen again. Continue this until the center image thins out and becomes diffuse. At this point the separation is too great. Move them back to the location where you get the widest possible soundstage without losing center-fill energy. In blind listening tests the preferred angle of separation, with listener at the apex, turned out to be 72°.

The next step is to adjust left to right balance. If the system components are adjusted for equal output from both channels, and the center image is not centered, it could be that one speaker is closer than the other. Compensate for this by moving one speaker slightly forward or backward. An excellent source for this procedure is a mono recording. If an instrument that should be centered sounds slightly to the right, the right speaker should be pushed back or the left moved forward. Often 1 inch movements are audible. It is also possible to get this very close before listening by measuring with a tape measure from the tweeter on each speaker to a fixed position on the listening chair.

The final step is to focus the soundstage. The basic technique involves rotating one speaker to change the dispersion pattern. This is easier to do with two people. Start with the speakers aimed slightly behind the listener's head again listening to music with

prominent center fill. While the listener listens for focus, (sometimes it helps to close your eyes) the other person rotates one speaker on the inside front spike. The listener signals to indicate the best speaker location. Listen for the size of the instrument and the energy. Usually a smaller energetic image indicates the best location. When this is done neither speaker has to be readjusted to "look" like the other. The reason the toe-in may not be symmetrical is that rooms are not symmetrical therefore reflections that affect dispersion are not symmetrical. Dispersion also varies according to speaker and crossover design. For example, Sonics speakers are designed so that off-axis response is similar to on-axis response. This will reduce side wall reflection problems and toe-in will not be as critical as in speakers with radically different on and off-axis response.

Here is a summary of the set-up steps:

1. Place the speakers for best bass performance. Front to back movements for deep bass and side-to-side for mid bass.

2. Separate speakers to optimize soundstage width.

3. Move one speaker to adjust left to right balance.

4. Adjust speaker toe-in for image focus.

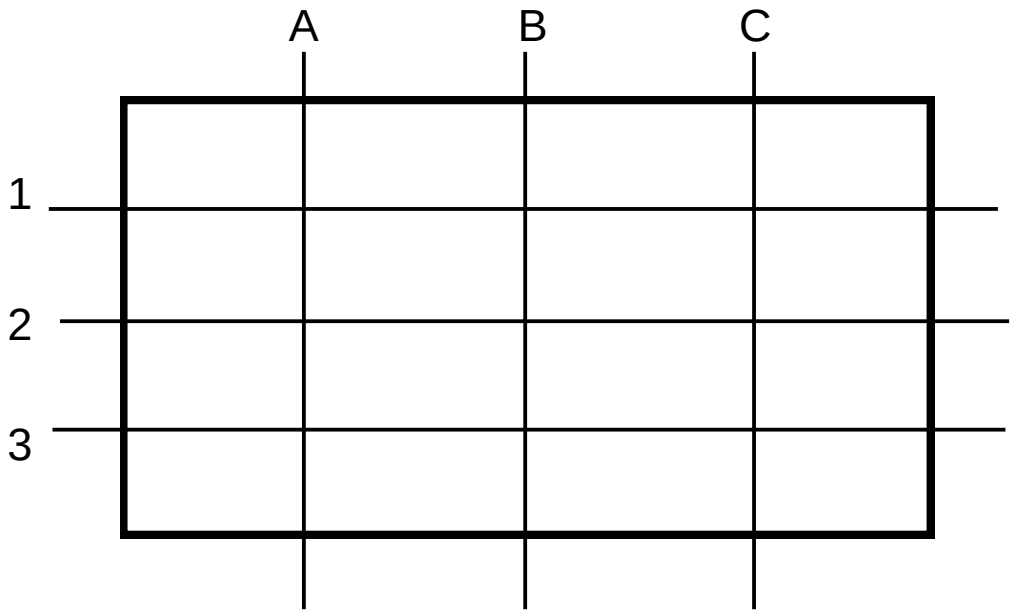
Here are some additional suggestions:

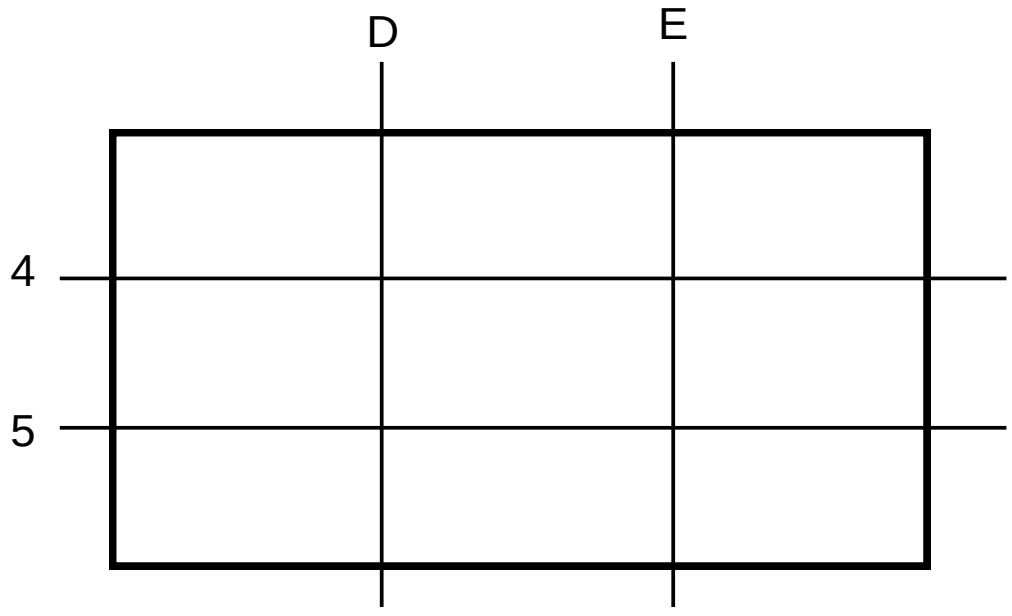
1. Because adjustments are interactive, the way to extract more performance from your system is to go through the set-up procedure again for "fine tuning".

2. When you are seated so that your head is close to a wall, some light damping material, (e.g. a small rug or heavy towel) directly behind your head may improve the sound. Also, at some point between the wall and 3 ft away, if you move your head forward and backward, you can hear changes in the apparent energy. This is a result of the slow wave velocity close to the room boundary. As you get a little farther from the wall the system will sound a little more "lively" but bass impact will drop. You can adjust your position to balance this out.

3. When fine-tuning for tonal balance the initial toe-in of the speakers affects the sound quite a bit. Listen to the difference between having the speaker pointed directly at your ear or straight ahead with no toe-in. You can adjust for a bright or dull room to some degree this way. Typically speakers pointed directly at the listener will sound more extended due to on-axis response having less roll-off of the highs. When speakers are pointed straight ahead the off-axis response will result in more energy reflecting off the side-walls and imaging will be more diffuse.

We hope that this information helps you maximize your speaker set-up and also gives you a better understanding of stereo sound. The best way to understand this information is to listen and experiment. Use the charts below to keep notes on your listening room.





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