Canalis

Principles and Techniques of Speaker Placement

After assembling a high-quality music system, the room becomes the limiting factor in sonic performance. There are many articles and theories on optimizing the interface between loudspeakers and the room, and also on methods of damping critical room resonances. Treatments used to damp room resonances with the goal of achieving a flat amplitude response are usually costly, and can result in a "lifeless" room sound. Also, designing speakers for a specific location, for example, speakers designed for wall placement, will limit placement options and give varied results according to the size of the room. Our approach is to examine how the room and speaker interact and create the best situation without the necessity of making radical changes to the room.

The Canalis solution limits the interference of the room through specific speaker placement and listening position, and by utilizing the effects of psychoacoustics and physics. This method gives superb results without the use of special room treatment; however, carefully used room treatment can provide further improvement.

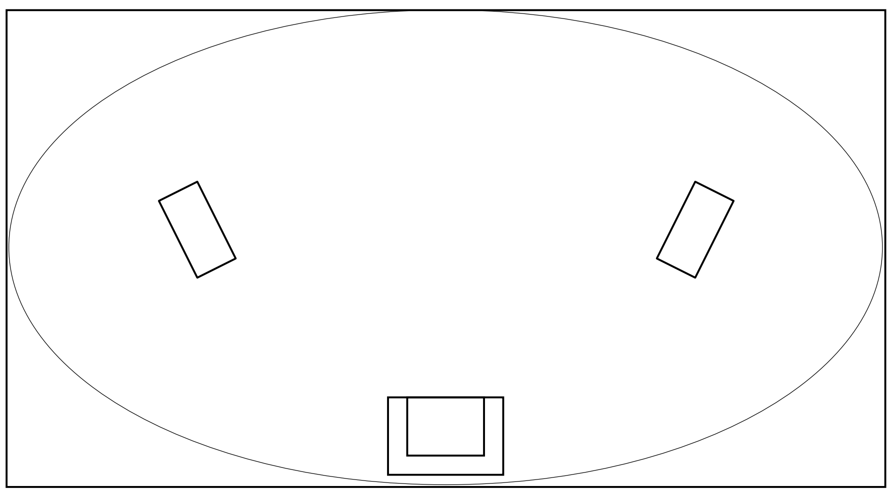
First, let's consider this information about how we hear. To locate where a sound is coming from, our brain senses the time between a sound arriving at one ear and then the other, or the *interaural time difference* (IAD). For example, if there is no difference in the time it takes a sound to reach each ear, the brain determines that the sound emanates directly in front of us. If the sound reaches the right ear first the brain determines that the sound is to the right and so on. The placement of where the sound is coming from is determined by the delay time, and the decision is made subconsciously and extremely fast. In fact, the brain determines location in the first 800µs of the initial transient, because this is the maximum time delay possible due to the distance between the left and right ear.

After this initial recognition of location, the perception of tonality starts. This has been shown in scientific studies and is believed to be a critical part of our survival as a species. In other words, we first locate the source of a sound, which could be a potential danger, for example, and then try to identify what made the sound.

Consequently, the first step to achieving a good stereo soundstage is to have the sound directly from the speakers arrive at your ears before any reflection of that sound. If the first transient from the primary source arrives sooner than any reflections it prevents any confusion as to where the sound is coming from. The scientific term for this psychoacoustic phenomenon is called the Haas effect. Also, if the speakers measure flat under anechoic conditions, the brain will perceive flat response when the first transient arrives before any reflections. So, even if measurements taken at the listening position show severe deviations in frequency response from reflections, the brain will ignore this and perceive a flat response. Because of this, one goal of speaker setup is to eliminate the earliest reflections, off the walls or windows for example.

An idealized example of these principles would be a well-proportioned listening room where the speakers are positioned at the two center points of an ellipsoid touching the walls of the room, as in the illustration below. The best listening position is centered between the speakers with your head one to three feet from the rear wall. In this location the sound from the speakers reaches the ears before any reflections from the side walls. The advantages are maximum possible speaker separation for the widest desirable soundstage, and maximum first-reflection delay. This will produce the best soundstage and perceived tonal balance.

The distance directly from the speaker to the ear should be at least five feet less than the distance from the speaker, to a reflective surface, to the ear. The reason for the 5-foot difference is that if the reflected sound arrives 5 milliseconds or more after the primary sound, the brain knows it is not the source. Sound travels 5 feet in 5 milliseconds. Here is an example of the formula to determine the best listening location. Assume the speaker to ear distance is 6 feet. Then the speaker to wall distance is 5 feet and wall to ear is 8 feet, so the total reflected distance is 13 feet. 13 feet for reflection – 6 feet from the source = 7 feet. 7 ft. is greater than 5 ft. so this will work.



So why did we place the listening chair near the rear wall? The first reason is bass reinforcement. Maximum sound pressure occurs at the room boundaries and pressure gives the sense of deep bass. Secondly, because the reflections off the rear wall are shorter than the circumference of the head, the brain cannot measure the time delay between the ears. If it cannot measure the time delay it cannot localize the source of sound. When the brain cannot localize reflections it ignores them.

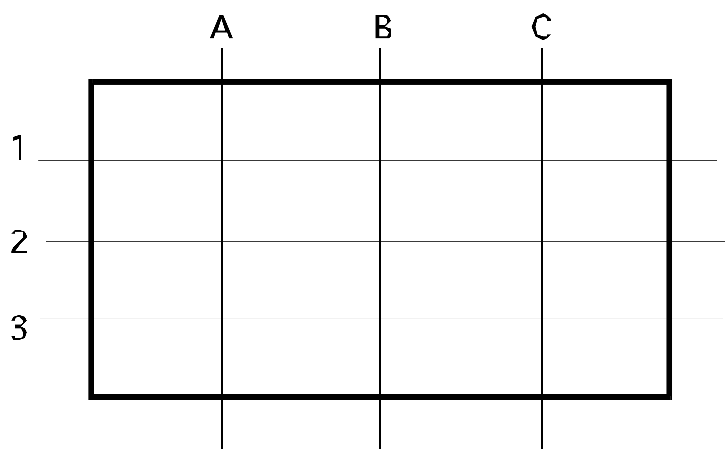
Here are some examples of the brain ignoring reflections or unessential information. Imagine being in a noisy public place and conversing with the person next to you. If you made a recording from where you are standing it would sound muddled or like random noise; however, you can isolate the conversation. If you hear your name mentioned from several feet away, you can change your focus and "listen in" on the other conversation. Another example is how we filter out the distracting natural resonance of a hallway to hear speech better. In a reflective sonic environment your brain will automatically "listen in" to the primary source and ignore the reflections.

To sum up:

- Locate the listening position so the first sound to arrive at the ears is directly from the speakers. Secondary reflections should arrive much later.
- Place the listening chair a distance of 1 to 3 ft from the rear wall. This way the time for the rear-wall reflections to reach the ears will be too short for the brain to locate the source.
- Finally, the wall is a room boundary, so the perception of deep bass is maximized when you sit close to the rear wall.

Let's expand on options for bass reinforcement, using a method we call room mapping. This method recognizes wave phenomena and that the nature of sound propagation in rooms is determined in large part by room dimensions. Mapping the room helps identify typical areas of bass cancellation and reinforcement so we can use that information to better locate the speakers.

First accurately measure the room (a tape measure is essential) and draw a simple floor plan. Divide the room into quarters. At even points in the room, bass frequencies are reinforced.

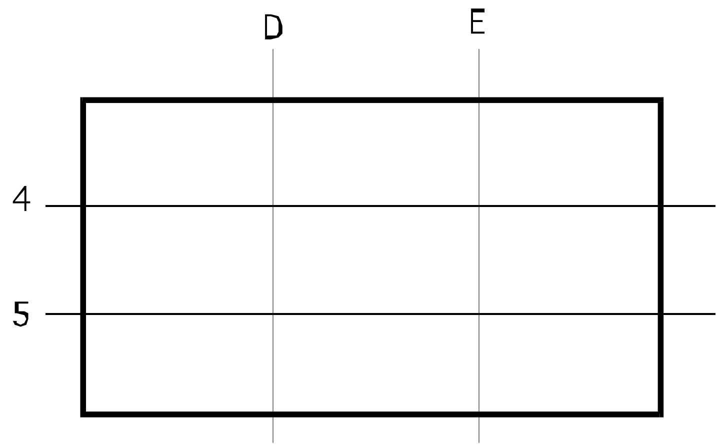


Referring to the above example, the cross points 2A and 2C are the ideal starting position for speaker placement. Place the listening chair at B less than 3 feet from the wall. This represents the seating arrangement in the first diagram.

If you want to set the speakers on the short wall, you can get good bass reinforcement by placing the listening chair against a wall at line 2 and placing the speakers at B1 and B3.

The next best speaker locations 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, place the chair at 2A and the speakers at C1 and C3. The disadvantage of these locations is a narrower distance between the speakers, which can result in a diminished soundstage, and increased sidewall reflections (which as we've seen can be problematic). Of course the final arrangement is usually determined by room size and furniture layout, but by placing the speakers and chair at an even division point of the room, you will get natural bass reinforcement.

Sometimes these arrangements result in too much bass. You can use the same principle to cancel rather than reinforce low frequencies. This gives you a method of tuning the bass and mid-bass by moving the speakers toward odd divisions of the room. The following illustration is another drawing of a room, divided into odd increments. The cross points are the locations with the least amount of 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.

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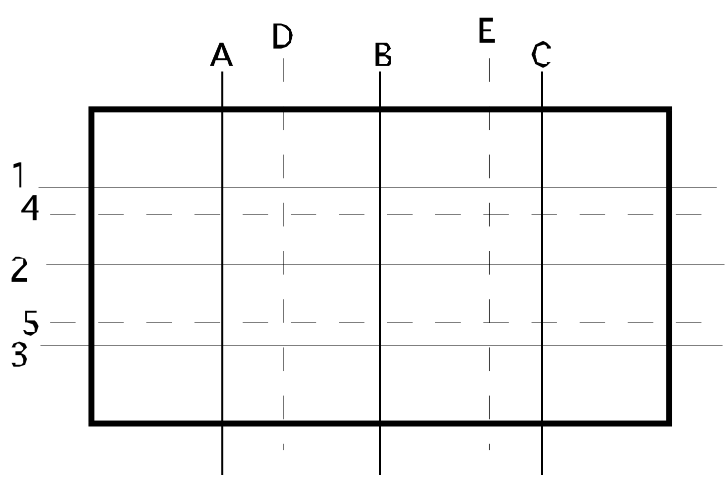
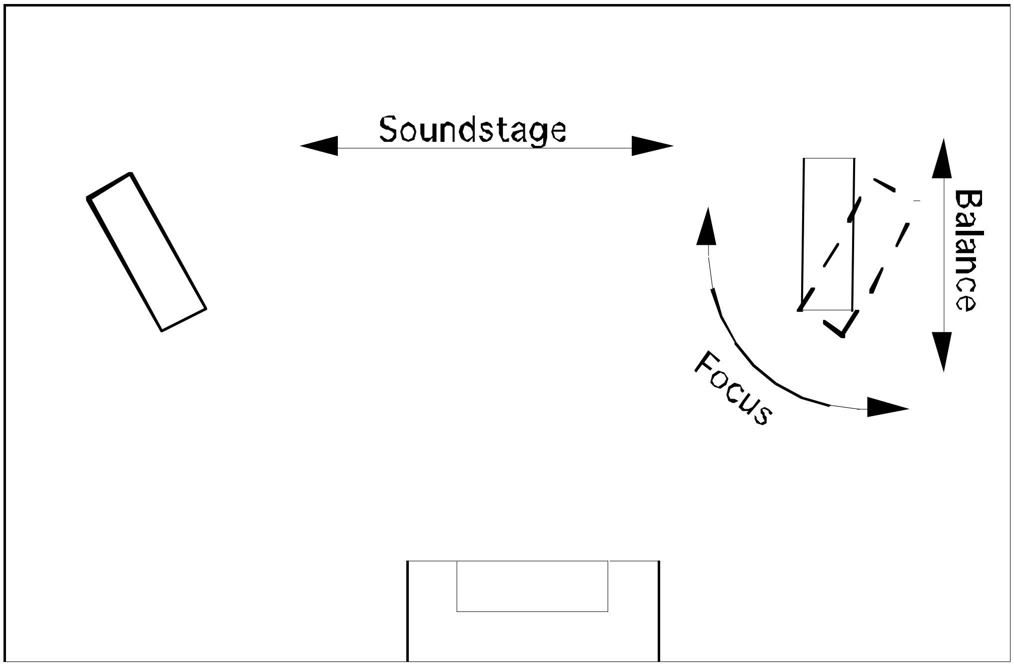


For tuning, the general tendency is for sideways movements to affect the mid-bass and forward and backward movements to affect lower bass.

After determining the general placement for best deep bass performance with the above room mapping technique, the next step is to determine the distance between the 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 listener's 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 speakers are too far apart. Move them back to the location that produces the widest possible soundstage without losing center-fill energy.



In blind listening tests the preferred angle turned out to be 72° with the listener at the apex. However, the optimum angle depends on the dispersion pattern of the specific type of speaker.

The next step is to adjust the balance. First, use a tape measure to achieve accurate positioning of the speakers by measuring the distance from the tweeter of each speaker to a fixed position on the listening chair. If the source and electronics are adjusted for equal output from both channels and the center image is not perfectly centered, it is usually because one speaker is closer to the listener than the other. Listen to a piece of music with strong center fill. An excellent source for this procedure is a mono recording. If the center fill is shifted to the right, the right speaker should be pushed back or the left moved forward. Move only one speaker slightly forward or backward until the image is centered. Often one-inch movements are audible.

The final step is to focus the soundstage. This is achieved by rotating one speaker, which changes its dispersion pattern at the listening position. This is much easier to do with two people. Start with both speakers aimed slightly behind the listener's head and play music with prominent center fill. While the listener listens for focus, (sometimes it helps to close your eyes), the other person rotates one speaker around the inside front spike. Listen for the size of the instrument and its overall "energy." Usually a more focused "energetic" image indicates the best location. The listener should signal to indicate the best focus.

When this is done, neither speaker should be readjusted to "mirror" the other. The reason the speakers may not be symmetrical is that rooms are not symmetrical, and the reflections that affect dispersion are not symmetrical. Because of this, different speaker angles can compensate for room anomalies. Dispersion also varies according to speaker and crossover design. For example, Canalis loudspeakers are designed so their off-axis response is similar to their on-axis response. This reduces sidewall reflection problems, and their toe-in adjustment will not be as critical compared to 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. Use front to back movements for deep bass and side-to-side adjustments for mid bass.

2. Adjust the distance between the speakers to optimize soundstage width.

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

4. Adjust the speaker toe-in for best 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 this set-up procedure again for "fine tuning."

2. When you are seated with your head close to a wall, some light damping material such as a small rug or heavy towel placed directly behind you may improve the sound.

3. If you move your head forward and backward, at some point between the wall and three feet away you can hear changes in the apparent energy. As mentioned in the discussion about bass, room boundaries are high-pressure areas. When pressure is high, the velocity of the sound wave is lower. As you get a little farther from the wall the system will sound a little more "lively" but bass impact will diminish. You can adjust your listening position to balance this out.

4. 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 in the high frequencies because of the on-axis response having less high frequency roll-off. When speakers are pointed straight ahead, the off-axis response will result in more energy reflecting off the sidewalls and imaging will be more diffuse.

We hope this helps you maximize your speaker setup and also gives you a better understanding of stereo sound. The best way to understand this information is to listen and experiment.

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