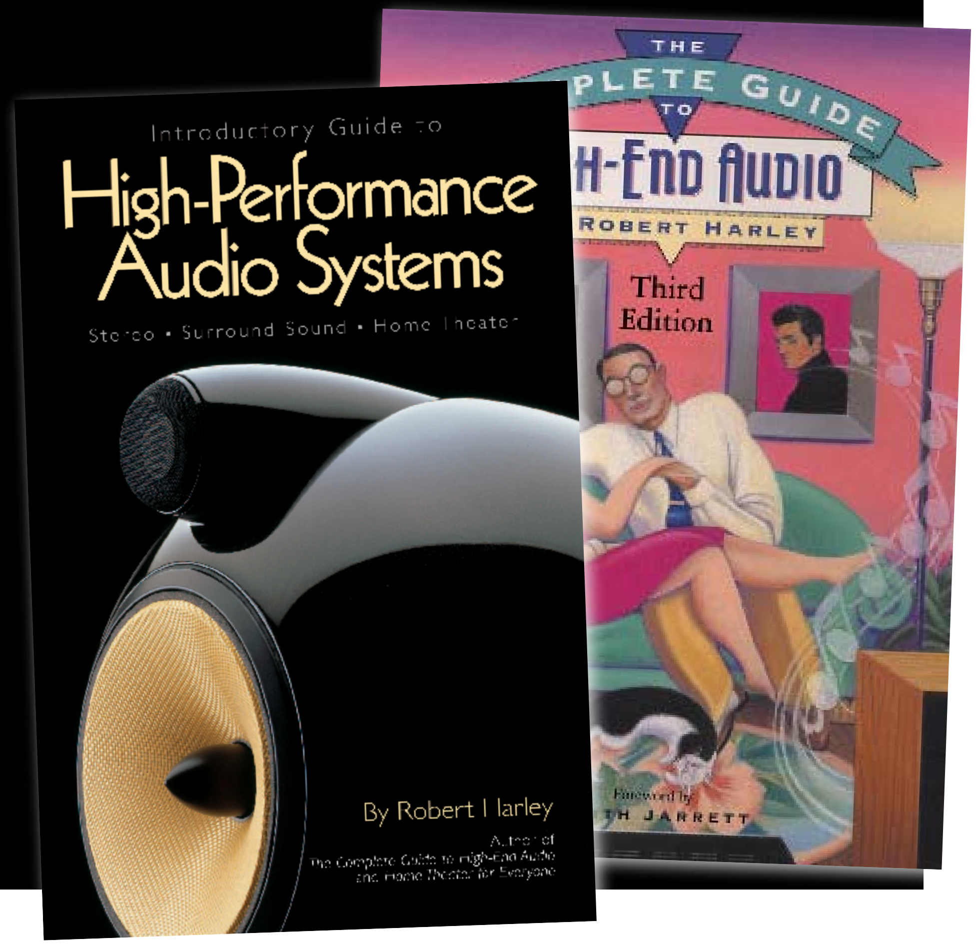
ROBERT HARLEY'S
SYSTEM SET-UP SECRETS

INSIDER TECHNIQUES FOR OPTIMIZING YOUR STEREO SYSTEM



Excerpted and Adapted from *The Complete Guide to High-End Audio* and *Introductory Guide to High-Performance Audio Systems*.

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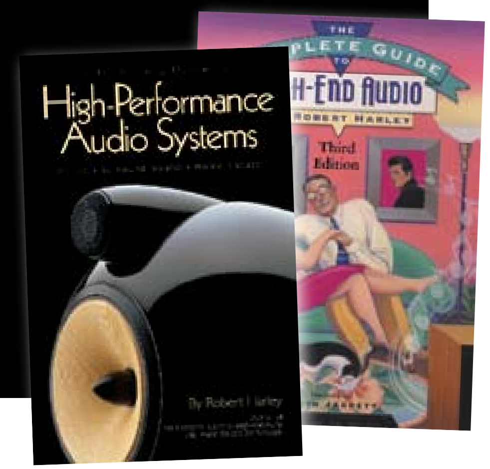

How an audio system is installed, set up, and fine-tuned has an enormous impact on that system's sound quality. You might have chosen some great individual audio components, but that doesn't guarantee you'll get great sound.

In this special booklet adapted from my books *The Complete Guide to High-End Audio* and *Introductory Guide to High-End Audio Systems*, I'll share with you some insider techniques for optimizing your hi-fi system.

I've learned these techniques from the world's greatest experts on system setup—the designers of high-end audio products. As a full-time reviewer for the past 20 years, I've closely watched these designers set up their products in my listening room. As you can imagine, they are highly motivated to get the best possible sound from the product under review. These designers pull out every trick they know to squeeze that last bit of performance from my system. System set-up is a fascinating and rewarding art that anyone can master.

Robert Harley

STARTING FROM SCRATCH

If you are new to high-end audio and installing your first "serious" stereo system in your home, you should re-think your room's layout to maximize the system's sound quality. Yes, it may seem extreme to rearrange your furnishings to accommodate your music system, but once you get used to hearing your favorite music wonderfully reproduced, it will all be worthwhile. In addition, I can assure you that music listening will assume a greater importance in your life.

OVERALL LOUDSPEAKER AND LISTENING POSITIONS

The first consideration is where to put the loudspeakers and listening couch or chair. We'll address the details of loudspeaker placement later, but we must first start with the correct geometric relationship between the two loudspeakers and the listener. The listener should sit exactly between the two loudspeakers, at a distance away from each loudspeaker slightly greater than the distance between the loudspeakers themselves. Though this last point is not a hard-and-fast rule, you should certainly sit exactly between the loudspeakers; that is, the same distance from each one. If you don't have this fundamental relationship, you'll never hear good soundstaging from your system.

Fig.1 shows how your loudspeaker and listening positions should be arranged. The listening position—equidistant from the speakers, and slightly farther from each speaker than the speakers are from each other—is called the "sweet spot." This is roughly the listening position where the music will snap into focus and sound the best. If you sit to the side of the sweet spot, the soundstage will tend to bunch up around one speaker. This bunching-up effect will vary with the loudspeaker; some loudspeakers produce a wider sweet spot than others.

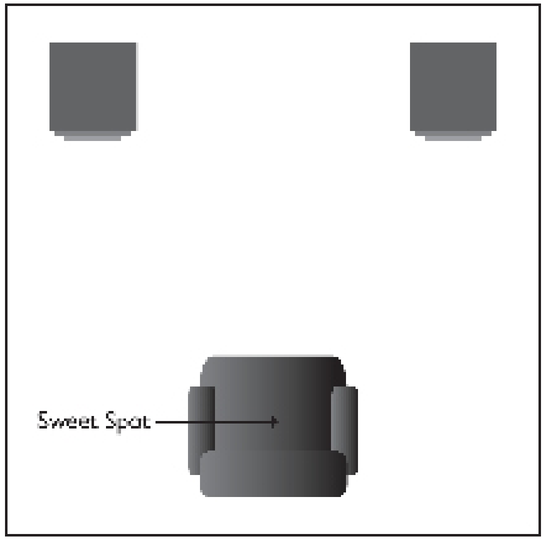

Fig.1 The "sweet spot" is the listening position where the sound snaps into focus.

TIP

The listener should sit exactly between the two loudspeakers, at a distance away from each loudspeaker slightly greater than the distance between the loudspeakers themselves.

Incidentally, don't install the spikes that came with your speakers yet. That will be the last step in the set-up process.

EQUIPMENT RACKS

Once you've determined the rough locations of your loudspeakers and listening seat, you must decide where and how to house your equipment. I highly recommend an equipment rack designed for high-performance hi-fi rather than a generic piece of furniture. You'll often see mid-fi audio gear housed in "stereo stands" with flimsy shelves. But to get the best performance from your high-end equipment, you'll need a solid, vibration-resistant platform for your components. A quality equipment rack does more than provide convenient housing for your equipment; it also isolates equipment from vibration.

There is no question that vibration degrades the sonic performances of preamplifiers, CD players, and particularly turntables. This vibration is generated by transformers in your components' power supplies, motors in turntables and CD players, and from acoustic energy impinging on the electronics. Yes, racks can have an audible effect on a system. A good equipment rack fights vibration with rigidity, mass, and careful design.

The massive, inert structure of a high-quality rack is much less likely to vibrate when in the presence of sound pressure generated by the loudspeakers. Moreover, the equipment rack can absorb, or damp, the vibration created by power transformers and motors. Many equipment racks have built-in vibration-damping mechanisms in their shelves.

Many equipment racks are supplied with spikes to couple the stand to the floor and "drain" vibration from the rack. For a spiked rack to be effective, the floor must be sturdy and flat so that the rack doesn't rock. The heights of most spikes are adjustable; you can level the rack and get good contact between the floor and all four (or three) spikes. Rack spikes are usually much heavier duty, with more rounded points than loudspeaker spikes. Note, however, that both types of spike will damage wood floors. Some racks are supplied with small plates to hold the spikes, preventing floor damage. A rack's performance can often be improved by adding aftermarket spikes, cones, or other vibration-isolation devices underneath your components. These devices further decouple the audio component from the rack and sometimes deliver a significant sonic improvement for a relatively small investment.

Avoid racks with large, unsupported shelves, flimsy construction, low mass, and poor vibrational damping. And don't even consider the generic "stereo stands" sold in furniture and department stores. Get a rack specially designed for high-performance audio systems. Consider a good equipment rack an essential part of your hi-fi system; it will help your system achieve its full musical potential.

You'll need to decide whether to house your equipment in an open-air rack or stand (Fig.2), or behind closed doors in a cabinet. The open-air rack is the preferred choice of audiophiles—it allows easier access to connections, affords better ventilation of heat-generating components, and showcases your gear.

Fig.2 A high-quality equipment rack will help your system achieve its full potential.

TIP

Don't even consider the generic "stereo stands" sold in furniture and department stores. Get a rack specially designed for high-performance audio systems.

POSITIONING THE EQUIPMENT RACK, CABLE CONSIDERATIONS, AND CABLE DRESSING

The equipment rack can be placed between the loudspeakers, to the side of the room, or in the back of the room behind the listening position. The decision of where to put your equipment rack will greatly influence the lengths of speaker cables and signal interconnects you'll need. Positioning your rack between the speakers allows you to use the shortest possible interconnects and loudspeaker cables. It's also a convenient location for changing discs and operating your system. If you choose this arrangement, however, you should make sure that the equipment rack is behind the speakers. That's because the rack and the equipment in it will reflect sound from the loudspeakers, degrading the system's soundstaging performance. As we'll discuss in detail later, it's a good idea to keep reflective objects away from the loudspeakers. Positioning your equipment rack a foot or more behind the loudspeakers will ensure that the rack doesn't adversely affect the system's sound quality.

If you position your rack to the side of the room, the loudspeaker cables will need to be longer. This assumes that you're using an integrated amplifier or a separate preamplifier and power amplifier, with the power amplifier housed in the equipment rack. Even though one speaker will be closer to the rack than the other speaker, keep the loudspeaker lengths identical. The excess speaker cable should be spread out across the floor rather than coiled behind the speaker or equipment rack.

Those of you with a preamplifier in the rack and a stereo power amplifier (or monoblock amplifiers) on the floor will need long interconnects to go from the preamp to the power amp. Again, keep the left-and-right-channel interconnect lengths identical. In this setup, the speaker cables can be quite short.

There's some debate in the high-end as to whether it's better to have short interconnects and long loudspeaker cables, or long interconnects and short loudspeaker cables. (I've asked a number of cable manufacturers their opinion on this issue. One wag said he thought all audiophiles should have long interconnects ***and*** long speaker cables.) In my experience, loudspeaker cables do more harm to the signal than interconnects, and thus should be as short as possible (but always the same length between the left and right channels). All cable degrades the signal passing through it; the less cable you have, the better. Loudspeaker cables carry much higher signal levels than interconnects; the electromagnetic distortions introduced by signals flowing through conductors are greater in speaker cables than in interconnects. In my current system the equipment rack is behind the listening position, with 24' interconnects from the preamplifier to power amplifiers and short speaker cables.

Some speakers have two pairs of binding posts for bi-wiring (connecting each speaker with two runs of cables rather than one). Bi-wiring can be an advantage with most loudspeakers. If you bi-wire, however, be sure to use identical cables in both runs. Different cables will have different electrical properties (inductance and capacitance) that will interact with the crossovers in the loudspeaker and change the performance the speaker designer intended.

If you have the choice of connecting your speakers with cables terminated with pins, spade lugs, or banana jacks, choose spade lugs. They provide the best electrical connection.

An accessory you should try once your system is set-up and fine-tuned is the Cardas RCA Caps. These are RCA shorting plugs that ground your preamplifier's unused inputs. The result is often a "blacker" background and an overall cleaner sound.

Provide adequate ventilation for heat-producing components. Don't stack a CD player on top of an integrated amplifier, for example. If you must stack components on a single rack shelf, separate them with cones or feet. Overheating may degrade performance, and will certainly shorten product life. If you have a power amplifier (or integrated amplifier) in your equipment rack, keep it as far as possible from a phono preamplifier (if your system uses one).

How the cables behind your equipment rack are routed can affect the sound. Keep AC cords away from signal-carrying cables. If they must meet, position them at right angles to each other rather than running them parallel to each other. AC cables radiate 60Hz hum that could be picked up by signal cables. Cables carrying digital data—the output from a CD transport, a DVD player, or other digital source—should be kept away from both AC cables and analog signal-carrying cables. Cables carrying digital data radiate noise that could get into the analog signal. A cheap and effective technique is to separate AC cables, digital cables, interconnects, and speaker cables from each other with foam blocks suspended between the cables. Shunyata Research makes a product called the "Dark Field Cable Elevators" that work well in this application. The Shunyata Elevators are specially designed and manufactured to conduct static electricity so that there's no static voltage between your cables. When used on the floor to elevate cables, the devices "short" the static charge between the cable and carpet.

> **TIP**
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> **If you have the choice of connecting your speakers with cables terminated with pins, spade lugs, or banana jacks, choose spade lugs. They provide the best electrical connection.**

When handling cables and interconnects, don't touch the jacks; your fingers will leave oil on the conductive surfaces. Before connecting your cables and interconnects for the first time, clean the jacks on the equipment, the interconnect plugs, loudspeaker binding posts, and loudspeaker cable terminations with a contact cleaner such as Caig DeoxIT. Ensure a good contact between the loudspeaker cables and binding posts. Use a nutdriver to get a tight fit, being careful not to over-tighten. Every six months or so, clean all the electrical contacts with DeoxIT. This cleaner also works well on vacuum-tube pins.

AC POWER CONDITIONERS

Once your equipment is housed in a rack or enclosed cabinet, you'll need to plug the gear into an AC power source. Rather than plug the components into an AC wall

Fig.3 An AC power conditioner is an important component of a high-end audio system.

socket, you should invest in an AC power conditioner. An AC power conditioner plugs into the wall outlet and provides multiple AC outlets for plugging in your audio equipment (Fig.3). An AC power conditioner is the single most important "accessory" you can add to your system. In fact, I consider an AC conditioner not just an accessory, but also an essential component of any high-performance audio system.

AC conditioners act in two ways to improve the sound of an audio system. First, AC conditioners filter noise from the AC line before it gets to your audio components. This noise on the AC power line is generated by light dimmers, refrigerators, motors, and household appliances. Industrial motors connected to the power grid also pollute the AC line with hash and high-frequency noise. This noise gets into the audio signal and degrades the sound.

A second source of dirty AC is your equipment itself. Any component using a microprocessor or other digital circuits (all digital source components, A/V controllers and receivers, and even some analog preamplifiers) put noise on the power line through their AC power-line cords. This noise then gets into your other components and reduces sound quality. The AC ground connects all the chassis of an audio system. If you've got a noisy ground on one component, you've got a noisy ground on all your components. For example, digital noise in a CD player's ground can get into your preamplifier, with the AC power line acting as a conduit for this noise.

All of these problems can be controlled with a well-designed AC power-line conditioner. First, nearly all conditioners filter the incoming AC line to remove the high-frequency garbage generated by factories, neighbors, and your own appliances.

The filters allow the 60Hz AC to pass, but remove noise from the line. Second, some filters isolate the components from each other with small isolation transformers on some of the conditioner's AC outlets. These transformers break the physical connection between components, preventing noise from traveling from one component to another. The isolated outputs are often marked "digital" for plugging in digital components, preventing a CD player from polluting the AC supplying the preamplifier, for example. Third, a good line conditioner will reduce the amount of noise coupled to signal ground. Finally, AC line conditioners can protect components from voltage spikes, lightning strikes, and surges in the power-supply voltage. Not all conditioners perform every function listed here; conditioners vary in their design principles, with some addressing one problem but not another.

When choosing a line conditioner, make sure its power capability exceeds the power consumption of the components you'll be plugging into it. Each component's owner's manual will state the component's power consumption in watts. Add together the individual power-consumption specs to determine the total amount of power to be drawn from the conditioner. Compare this number with the power conditioner's maximum rated power delivery. Also look for the UL (Underwriters Laboratories) or CSA (Canadian Standards Association) seal of approval, indicating that the power conditioner meets certain safety requirements. Choose a conditioner with a sufficient number of outlets for your present and anticipated needs. As with all accessories, try the power conditioner in your system before you buy. Expect to pay a minimum of $200 for a conditioner with just a few outlets, to several thousand dollars for a state-of-the-art system. Many excellent conditioners cost less than $500.

TIP

Keep AC cords away from signal-carrying cables. If they must meet, position them at right angles to each other rather than running them parallel to each other.

A power-line conditioner can't make poor audio components sound good; instead, it merely provides the optimum AC environment for those components so that they may realize their full potentials. The sonic benefits of a good line conditioner include a "blacker" background, with less low-level grunge and noise. The music seems to emerge from a perfectly quiet and black space, rather than a grayish background.

The treble often becomes sweeter, less grainy, and more extended. Soundstaging often improves, with greater transparency, tighter image focus, and a newfound soundstage depth. Midrange textures become more liquid, and the presentation has an ease and musicality not heard without the conditioner.

Not all conditioners improve the sound, however. I recommend setting up your system initially without an AC conditioner and living with it for a few weeks. When you do add a conditioner, you'll be able to immediately identify whether the conditioner rendered an improvement or not. Most dealers will allow you to return or trade in (for full value) a conditioner you've had for just a few days if it doesn't work well in your system.

EQUIPMENT SET-UP SUMMARY

- Keep interconnects and AC power cords separated behind the equipment rack and on the floor. If they must meet, position them at right angles to each other instead of parallel.
- Keep digital data interconnects (between a separate CD transport and digital processor) and analog interconnects between source components and your preamplifier separate from each other. The very high frequencies carried by digital cables can radiate noise and pollute analog signals.

- Turn off your digital components when playing LPs.

- Keep interconnects and loudspeaker cables as short as possible, but always the same length between left and right.

- Position components for adequate ventilation. Overheating will shorten product life.

- Ensure good contact between loudspeaker cables and binding posts. Get the spade lug fully on the binding post and tighten with a nut driver.

- Clean plugs and jacks periodically with contact cleaner.

- Maintain adequate distance between the preamplifier and power amplifier. The power amp's large transformer can radiate 60Hz hum. This is more crucial in preamplifiers with phonostages or with separate phono preamps.

- Install the equipment on a sturdy stand. Vibration can degrade system performance, particularly that of turntables.

- Don't use light dimmers or fluorescent lighting in the listening room. Dimmers put lots of noise in the AC line, which gets into your components through their AC cords.

- Experiment with AC power conditioners. They make a huge improvement in some systems, none in others, and can sometimes degrade system performance. Listen before you buy. Some of these set-up techniques may seem overly perfectionist, or capable of rendering a very small improvement in sound quality at best. But all have the potential of increasing the performance of your system, and when combined, can result in a significant sonic gain. Taking your system to the next level of performance with these products and techniques requires patience, listening skill, and a desire to extract the last bit of performance. As your system's sound improves—and your set-up skills sharpen—you'll become more attuned to small performance variations. It's extremely rewarding to improve the sound of a hi-fi system simply by using your knowledge and skill.

As important as these set-up techniques are, however, there's one that trumps them all—correct loudspeaker positioning. All of the set-up tricks I've just described should be based on the foundation of good loudspeaker placement.

LOUDSPEAKER PLACEMENT

Finding the right spot for your loudspeakers is the single most important factor in getting good sound from your system. Loudspeaker placement affects tonal balance, the quantity and quality of bass, soundstage width and depth, midrange clarity, articulation, and imaging.

As you make large changes in loudspeaker placement, then fine-tune placement with smaller and smaller adjustments, you'll hear a newfound musical rightness and seamless harmonic integration to the sound. When you get it right, your system will come alive. Best of all, it costs no more than a few hours of your time.

Before getting to specific recommendations, let's cover the six fundamental factors that affect how a loudspeaker's sound will change with placement. (Later we'll look at each of these factors in detail.)

1) The relationship between the loudspeakers and the listener is of paramount importance. The listener and loudspeakers should form a triangle; without this basic setup, you'll never hear good soundstaging and imaging. (See Fig.1 earlier)

2) Proximity of loudspeakers to walls affects the amount of bass. The nearer the loudspeakers are to walls and corners, the louder the bass.

3) The loudspeaker and listener positions in the room affect the audibility of room resonant modes. Room resonant modes are reinforcements at certain frequencies that create peaks in the frequency response, which can add an unnatural "boominess" to the sound. When room resonant modes are less audible, the bass is better defined, and midrange clarity increases.

4) The farther out into the room the loudspeakers are, the better the soundstaging—particularly depth.

5) Listening height affects tonal balance.

6) Toe-in (angling the loudspeakers

TIP

Positioning your equipment rack a foot or more behind the loudspeakers will ensure that the rack doesn't adversely affect the system's sound quality.

toward the listener) affects tonal balance (particularly the amount of treble), soundstage width, and image focus.

Let's look at each of these factors in detail.

1) Relationship between the loudspeakers and the listener

The most important factor in getting good sound is the geometric relationship between the two loudspeakers and the listener (we aren't concerned about the room yet). The listener should sit exactly between the two loudspeakers, at a distance away from each loudspeaker slightly greater than the distance between the loudspeakers themselves. Though this last point is not a hard-and-fast rule, you should certainly sit exactly between the loudspeakers—that is, the same distance from each one. If you don't have this fundamental relationship, you'll never hear good soundstaging from your system.

Fig.1, shown earlier, illustrates how your loudspeaker and listening positions should be arranged. This is such a fundamental prerequisite to good sound that I'll repeat this section. The listening position—equidistant from the speakers, and slightly farther from each speaker than the speakers are from each other—is called the "sweet spot." This is roughly the listening position where the music will snap into focus and sound the best. If you sit to the side of the sweet spot, the soundstage will tend to bunch up around one speaker. This bunching-up effect will vary with the loudspeaker; some loudspeakers produce a wider sweet spot than others.

Setting the distance between the loudspeakers is a trade-off between a wide soundstage and a strong center image. The farther apart the loudspeakers are (assuming the same listening position), the wider the soundstage will be. As the loudspeakers are moved farther apart, however, the center image weakens, and can even disappear. If the loudspeakers are too close together, soundstage width is constricted.

The best listening angle will produce a strong center image and a wide soundstage. You can experiment with angle simply by moving your listening chair forward and backward. There will likely be a position where the center image snaps into focus, appearing as a stable, pinpoint spot exactly between the loudspeakers. A musical selection with a singer and sparse accompaniment is ideal for setting loudspeaker spacing and ensuring a strong center image. With the loudspeakers fairly close together, listen for a tightly focused image exactly between the two loudspeakers. Move the loudspeakers a little farther apart and listen again. Repeat this move/listen procedure until you start to hear the central image become larger, more diffuse, and less focused, indicating that you've gone slightly beyond the maximum distance your loudspeakers should be from each other for a given listening position. Move the speakers slightly closer together until the image snaps into focus again—you've just found the optimum separation of your speaker for a given listening distance.

A factor to consider in setting this angle is the relationship to the room. You can have the same geometric relationship between loudspeakers and listener with the loudspeakers close together and a close listening position, or with the loudspeakers far apart and a more distant listening position. At the distant listening position, the listening room's acoustic character will affect the sound more than at the close listening position. That's because at the close position you hear more direct sound from the loudspeaker and less reflected sound from the room's walls. Consequently, the farther away you sit, the more spacious the sound. The closer you sit, the more direct and immediate the presentation. Some loudspeakers need a significant distance between the loudspeaker and the listener to allow the loudspeakers' individual drive units to integrate. If you hear a large tonal difference just by sitting closer, you should listen from a point farther away from the speakers.

2) Proximity to walls affects the amount of bass

The room boundaries have a great effect on a loudspeaker's overall tonal balance. Loudspeakers placed close to walls will exhibit a reinforcement in the bass (called "room gain"), making the musical presentation weightier. Some loudspeakers are designed to be near a rear wall (the wall behind the speakers); they need this reinforcement for a natural tonal balance. These loudspeakers sound thin if placed out into the room. Others sound thick and heavy if not at least 3' from the rear and sidewalls. Be sure which type you're buying if your placement options are limited.

When a loudspeaker is placed near a wall, its bass energy is reflected back into the room essentially in phase with the loudspeaker's output. This means the direct and reflected waves reinforce each other at low frequencies, producing louder bass. Fig.4 shows the difference in a loudspeak-

TIP

Loudspeaker placement affects tonal balance, the quantity and quality of bass, soundstage width and depth, midrange clarity, articulation, and imaging.

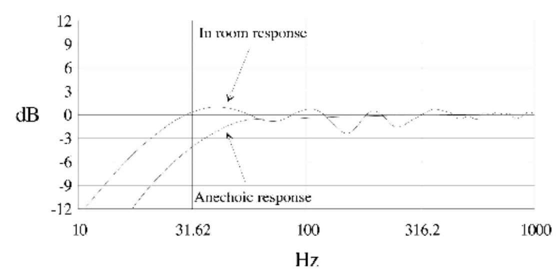


Fig.4 A room modifies a speaker's frequency response.

er's frequency response when measured in an anechoic chamber (a reflection-free room) and in a normal room. A frequency-response graph plots amplitude (loudness) vs. frequency. As you can see in the graph, not only is the bass boosted, but the loudspeaker's low-frequency extension is also increased. Each surface near the loudspeaker (floor, rear wall, and sidewalls) will add to the loudspeaker's bass output. The closer to the corners the loudspeakers are placed, the more bass you'll hear.

The loudspeaker's position in relation to the rear and sidewalls will also affect which frequencies are boosted. Correct placement can not only extend a loudspeaker's bass response by complementing its natural rolloff, but also avoid peaks and dips in the response. Improper placement can cause frequency-response irregularities that color the bass. That is, some frequencies are boosted relative to others, making the bass reproduction less accurate. The graph of Fig.5a is a loudspeaker's in-room response (the speaker's response as modified by the listening room) when placed equidistant from the rear and sidewalls. Note the 10dB notch (reduction in energy) at about 200Hz and the peak centered at 60Hz. The result will be boominess in the bass and leanness in the midbass. Moving the loudspeaker different distances from the rear and sidewalls can make the response much smoother (Fig.5b).

These graphs illustrate that a loudspeaker's room position affects the bass response, and that the loudspeakers should be positioned at different distances from the rear and sidewalls. A rule of thumb: the two distances shouldn't be within 33% of each other. For example, if the loudspeaker is 3' from the sidewall, it should also be at least 4' from the rear wall.

Many loudspeaker manufacturers will specify the correct distance from the rear and sidewalls. When a measurement is specified, the distance is between the woofer cone and the wall. Start with the loudspeakers in the locations recommended by the manufacturer, then begin experimenting.

How close the loudspeakers are to the sidewalls affects the amplitude of the sidewall reflection. The closer the loudspeakers are to the sidewalls, the higher the level of the sidewall reflections reaching the listener—not a good thing. If you've treated the sidewalls as described later in this section, putting the loudspeaker closer to the sidewall won't have as great an effect than if the sidewalls were left untreated.

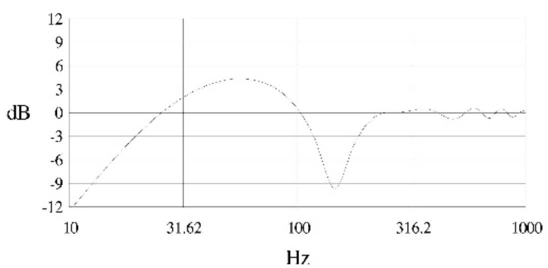


Fig.5a Positioning a speaker equidistant from the rear wall and sidewall creates severe peaks and dips in the frequency response.

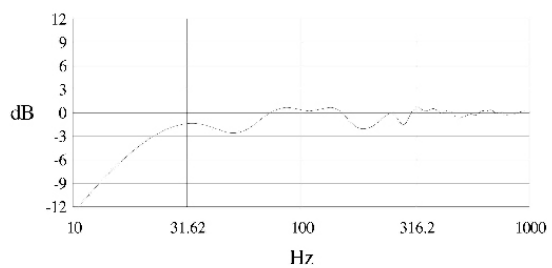


Fig.5b This plot is the same speaker as in Fig.5a, but in a better location. Note the much smoother and flatter bass response.

A highly effective technique for finding the best distances from the rear and sidewalls was developed by David Wilson of Wilson Audio Specialties. Stand at the rear wall about the same distance from the sidewall as you expect the loudspeakers to end up. Bend over and begin speaking, moving in a line perpendicular to the rear wall. Listen to the timbre of your voice as you move. You'll hear different colorations as you move, and then suddenly, at one particular location, your voice will sound open, clear, and uncolored. There will be a small range (several inches) over which your voice sounds the most natural. Mark this area on the floor with masking tape. This is the best distance from the rear wall for your loudspeakers. Now repeat this exercise, but starting on the sidewall at the same plane at which you have placed the masking tape. The point at which your voice sounds the clearest is the best distance from the sidewall to locate your loudspeaker. The two points will intersect, indicating where you should position the loudspeaker. The intersection should be just behind the loudspeaker's front baffle and centered on the woofer. This technique is very effective, and correlates very well with the placement suggested by computer modeling. The accuracy can be improved by having someone sit in the listening position as you move and speak, and confirm the point at which your voice sounds least colored.

> **TIP**
>
> **Setting the distance between the loudspeakers is a trade-off between a wide soundstage and a strong center image.**

3) Loudspeaker and listener positions affect room-mode audibility

In addition to deepening bass extension and smoothing bass response, correct loudspeaker placement in relation to the room's walls can also reduce the audible effects of your room's resonant modes. Room resonant modes are reinforcements at certain frequencies that create peaks in the frequency response. Room modes also create standing waves, which are stationary patterns of high and low sound pressure in the room that color the sound. The standing-wave patterns in a room are determined both by the room's dimensions and by the position of the sound source in the room. By putting the loudspeakers and listener in the best locations, we can achieve smoother bass response.

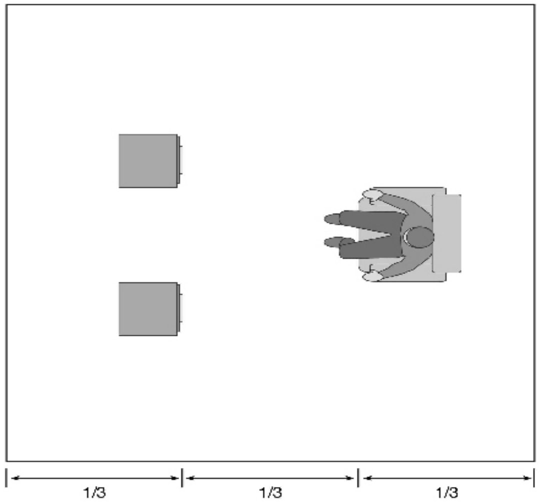


Fig.6 The "rule of thirds" says that for the best bass response, position the speakers a third of the way into the room.

A well-known rule of thumb states that, for the best bass response, the distance between the loudspeakers and the rear wall should be one-third of the length of the room (Fig.6). If this is impractical, try one-fifth of the room length. Both of these positions reduce the excitation of standing waves and help the loudspeaker integrate with the room. Ideally, the listening position should be two-thirds of the way into the room.

Starting with these basic configurations, move the loudspeakers and the listening chair in small increments while playing music rich in low frequencies. Listen for smoothness, extension, and how well the bass integrates with the rest of the spectrum. When you find the loudspeaker placement where the bass is the smoothest, you should also hear an increase in midrange clarity and definition.

An excellent test signal for evaluating bass and midrange sound in a room is the Music Articulation Test Tone (MATT) developed by Acoustic Sciences Corporation (ASC). This special test signal is a series of tone bursts that rise in pitch, with silences between the bursts. Ideally, you should hear the bursts and silences as separate events. When heard through headphones or with your ear near the loudspeaker, each burst is clearly articulated. But when the sound is modified by the listening room, certain frequency bands of the ascending tone bursts become smeared or garbled, indicating that the listening room is storing, and then releasing, energy at those frequencies. By moving the loudspeakers and listening to the MATT, you can easily discover where your loudspeakers work best in the room. (The MATT is available on *Stereophile*'s Test CD 2, which also includes more detailed information about how to use this unique test signal. This disc is available at tubetrap.com.)

4) Distance from rear wall affects soundstaging

Generally, the farther away from the rear wall the loudspeakers are, the deeper the soundstage. A deep, expansive soundstage is rarely developed with the loudspeakers near the rear wall. Pulling the loudspeakers out a few feet can make the difference between poor and spectacular soundstaging. Unfortunately, many living rooms don't accommodate loudspeakers far out into the room. If the loudspeakers must be close to the rear wall, make the rear wall acoustically absorbent.

5) Listening height and tonal balance

Most loudspeakers exhibit changes in frequency response with changes in listening height. These changes affect the midrange and treble, not the bass balance. Typically, the loudspeaker will be brightest (i.e., have the most treble) when your ears are at the same height as the tweeters, or on the tweeter axis. Most tweeters are positioned between 32" and 40" from the floor to coincide with typical listening heights. If you've got an adjustable office chair, you can easily hear the effects of listening axis on tonal balance.

The degree to which the sound changes with height varies greatly with the loudspeaker. Some models have a broad range over which little change is audible; others can exhibit large tonal changes when you merely straighten your back while listening. Choosing a listening chair that sets your ears at the optimum axis will help achieve a good treble balance.

6) Toe-in

Toe-in is pointing the loudspeakers inward toward the listener rather than facing them straight ahead (see Fig.7). There are no rules for toe-in; the optimum amount varies greatly with the loudspeaker and the listening room. Some loudspeakers need toe-in; others work best firing straight ahead. Toe-in affects many aspects of the musical presentation, including mid- and high-frequency balance, soundstage focus, sense of spaciousness, and immediacy. Most loudspeakers are brightest directly on-axis (directly in front of the loudspeaker). Toe-in thus increases the amount of treble heard at the listening seat. An overly bright loudspeaker can often be

TIP

Pulling the loudspeakers out a few feet from the back wall can make the difference between poor and spectacular soundstaging.

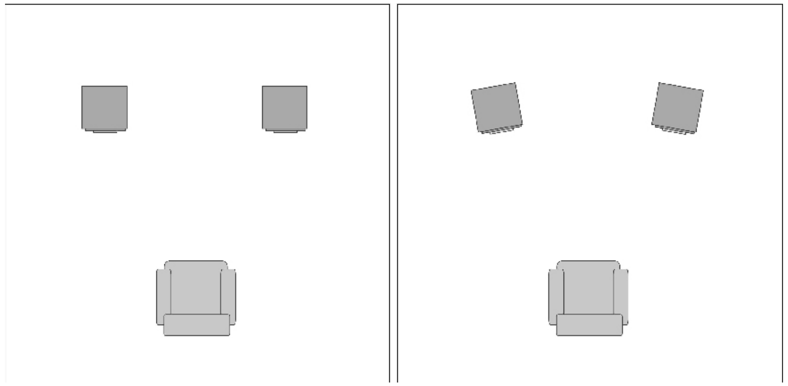


Fig.7 Speakers positioned with no toe-in (left) and with toe-in (right).

tamed by pointing the loudspeaker straight ahead. Some models, designed for listening without toe-in, are far too bright on-axis.

The ratio of direct to reflected sound increases with toe-in. That's because a toed-in loudspeaker will present more direct energy to the listener and project less energy into the room, where it might reach the listener only after reflecting from room surfaces. In a listening room with reflective sidewalls, toeing-in the loudspeakers can be a decided advantage. Moreover, the amplitude of sidewall reflections is greatly decreased with toe-in. Conversely, less toe-in increases the amount of reflected energy heard by the listener, adding to a sense of spaciousness and air. Reducing toe-in can open up the soundstage and create a feeling of envelopment.

Similarly, toe-in often increases soundstage focus and image specificity. When toed-in, many loudspeakers provide a more focused and sharply delineated soundstage. Images are more clearly defined, compact, and tight, rather than diffuse and lacking a specific spatial position. The optimum toe-in is often a trade-off between too much treble and a strong central image. With lots of toe-in, the soundstage snaps into focus, but the presentation is often too bright. With no toe-in, the treble balance is smoother, but the imaging is more vague.

Toe-in also affects the presentation's overall spaciousness. No toe-in produces a larger, more billowy, less precise soundstage. Instruments are less clearly delineated, but the presentation is bigger and more spacious. Toeing-in the loudspeakers shrinks the apparent size of the soundstage, but allows more precise image localization. Again, the proper amount of toe-in depends on the loudspeaker, room, and personal preference. There's no substitute for listening, adjusting toe-in, and listening again.

Identical toe-in for each loudspeaker is vital. This is most easily accomplished by measuring the distances from the rear wall to each of the loudspeaker's rear edges; these distances will differ according to the degree of toe-in. Repeat this procedure on the other loudspeaker, adjusting its toe-in so that the distances match those of the first loudspeaker. Another way to ensure identical toe-in is to sit in the listening seat and look at the loudspeakers' inside edges. You should see the same amount of each loudspeaker cabinet's inner side panel. Identical toe-in is essential to soundstaging because the speaker's frequency response changes with toe-in, and identical frequency response from both speakers is an important contributor to precise image placement within the soundstage.

Keep in mind that all loudspeaker placement variations are interactive with one another, particularly toe-in and the distance between loudspeakers. For example, a wide soundstage can be achieved with narrow placement but no toe-in, or wide placement with extreme toe-in.

TIP

An overly bright loudspeaker can often be tamed by pointing the loudspeaker straight ahead.

ONE FINAL TECHNIQUE

After you've used these techniques to dial-in the sound, there's one last nudge that can improve upon the sound quality you've achieved. Play a recording you know well, listen, and then very slightly move the speaker toward or away from the sidewall—an eighth of an inch or less. It's more of a nudge than a movement. Listen again to determine if the movement increased or decreased the sense of articulation and clarity in the midrange. Choose the position that sounds the best.

There's a theory behind this final adjustment. As described later in this section, when sound from the speaker reaches your ears directly as well as after being reflected from the sidewall, comb-filtering occurs. Comb-filtering is a series of narrow "notches" in the frequency response caused when the direct and reflected waves combine and cancel. The frequencies of these notches are determined by the distance between the speaker and the sidewall. When the speaker is a certain distance, those notches might happen to occur at musical frequencies. At a slightly different distance, those notches might occur at non-musical frequencies (non-musical at least in Western music) and the resulting coloration much less apparent.

LOUDSPEAKER PLACEMENT IN ASYMMETRICAL ROOMS

So far we've covered loudspeaker placement in a room that is symmetrical and bounded on four sides. But what about those listening rooms in which one side is open to the rest of the house, or rooms in which proper loudspeaker placement is difficult? Fortunately, you can still get good sound in these odd-shaped rooms.

Let's first consider the room in which one wall is essentially missing, where the listening room opens to the rest of the house (Fig.8). The left loudspeaker will introduce more room gain than the right speaker because of its proximity to the corner. Remember that the closer the speaker is to

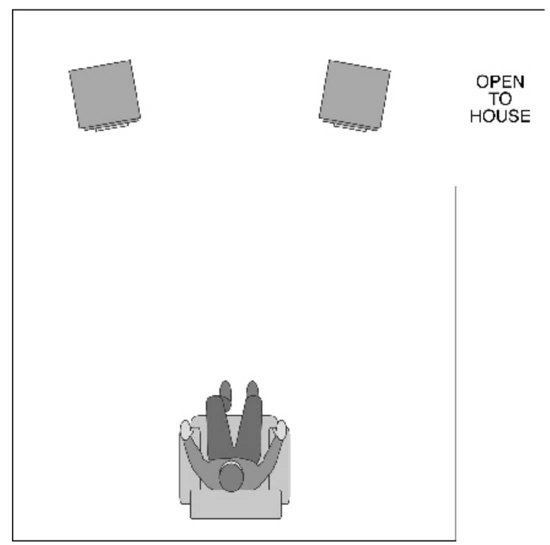


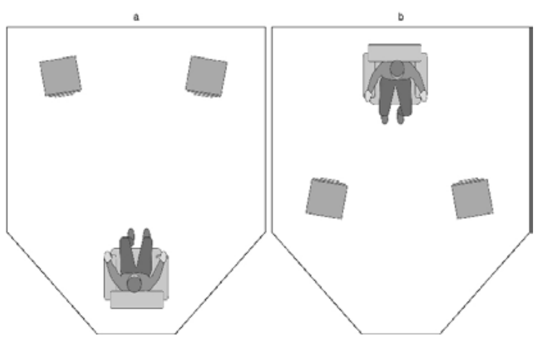
Fig.8 An asymmetrical room will cause one speaker to have more bass than the other.

TIP

Treating sidewall reflections is simple: Just put an absorbing or diffusing material on the sidewalls between the loudspeakers and the listening position.

walls, the greater the amount of bass. The right speaker has much less bass reinforcement, creating a bass imbalance.

The solution is two-fold. First, keep the speakers fairly far from the rear wall. This minimizes the room gain for the left loudspeaker, making its response more closely match that of the right speaker. Second, install a bass absorber (such as an ASC Tube Trap) in the corner behind the left loudspeaker. This trap will absorb bass energy rather than reflect it back into the room, and thus mimic the lack of room reinforcement from the right loudspeaker. You'll never be able to get a precise match, but these two



Figs.9a and 9b The speaker and listening position in 9a (left) direct unwanted sidewall reflections toward the listener. Fig.9b (right) shows a better placement.

techniques should get the two speakers close in bass output. I had a listening room for about two years that looked like Fig.8, and got good results with a 16" ASC Full Round Tube Trap in the left corner behind the loudspeaker.

If a room has non-parallel walls, try to position the loudspeakers at the room's narrow end. Figs.9a and b show incorrect and correct loudspeaker placement in such a room. The problem with the placement shown in Fig. 9a (left) is that detrimental sidewall reflections are directed at the listening position. In Fig.9b (right) sidewall reflections are naturally directed away from the listener. Many recording-studio control rooms are narrower at the speaker location for just this reason.

SHORT-WALL VS. LONG-WALL PLACEMENT

The examples shown have all assumed that the loudspeakers will be placed on the room's short wall. This traditional method provides the maximum space for bringing the loudspeakers out into the room and away from the rear wall. But putting the speakers on the long wall (Fig.10) also has some advantages.

Long-wall placement results in more direct sound at the listening position and less sidewall-reflected energy. This confers a large advantage in tonal purity and soundstage accuracy, for reasons described earlier. You hear more of the speaker and less of the room. The sound tends to be more immediate, detailed, and present.

Long-wall placement works only when the room is wide enough to accommodate some space between the speakers and the wall behind them, space between the speakers and listening position, and some space between the listener and the wall behind the listening position. If you sit with your head very near the wall behind you, the sound will likely be boomy. Consequently, you end up sitting fairly close to the loudspeakers with long-wall placement in all but very large rooms. Loudspeakers with first-order crossovers require significant space between speakers and listener for the sound of the individual drivers to properly integrate. If you sit too close to a speaker with first-order crossovers, the tonal balance will be wrong. Consider the room's width and the type of crossovers in your loudspeakers when deciding if long-wall placement is right for you. The reduction

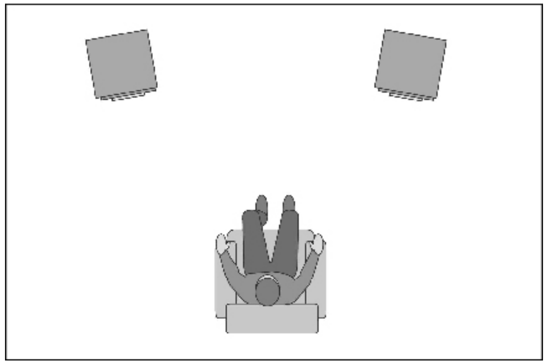


Fig.10 Positioning the speakers on a room's long wall reduces unwanted sidewall reflections.

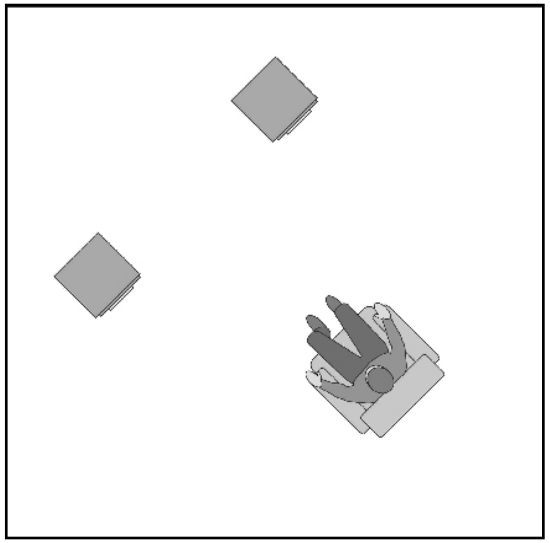


Fig.11 This unusual placement is often optimum in small rooms.

in reflected sound at the listening position with long-wall placement is a considerable advantage.

Finally, you may consider placing your loudspeakers at an odd angle in relation to the room, as shown in Fig.11. I've seen loudspeaker designers use this technique when trying to get good sound in a small hotel room at hi-fi shows. This placement, which works best for small speakers, has the advantage of reducing sidewall reflections at the listening position. The disadvantages are that it consumes much of the room's floor space and positions the speakers closer to walls, where the bass will be reinforced. That's why this technique is more successful with small speakers that have limited bass extension.

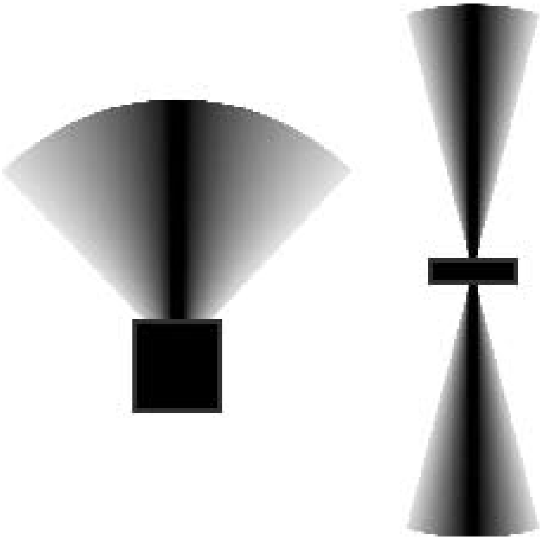


Fig.12 A monopole loudspeaker (left) directs sound in one direction; a dipolar loudspeaker (right) produces sound equally to the front and rear.

DIPOLAR AND BIPOLAR LOUDSPEAKER PLACEMENT

Dipolar loudspeakers produce sound to the rear as well as to the front (Fig.12). An electrostatic speaker is a dipole because the vibrating diaphragm sits in open space rather than a cabinet, launching sound equally to the front and rear. This rear wave from dipolar speakers is out of phase with the front wave; that is, when the diaphragm moves forward to create positive pressure in front of the diaphragm, it creates negative pressure behind the diaphragm.

A bipolar speaker typically uses arrays of conventional dynamic drivers on the front and rear of the loudspeaker enclosure. The front and rear waves from a bipolar speaker are in phase with each other. That's the difference between dipolar and bipolar: a dipole's rear wave is out of phase with the front wave, and a bipole's rear wave is in phase with the front wave.

What concerns us here, however, are the special placement requirements of bipolar and dipolar loudspeakers, along with the different ways in which they interact with the listening room. The most important consideration when positioning dipoles is that the wall behind the speakers (the rear wall) has a much greater influence on the sound than it does with conventional point-source speakers (those that direct energy in only one direction). Conversely, how the sidewalls are treated is less important with dipoles because they radiate very little energy to the sides and toward the ceiling.

Generally, dipoles like a reflective rear wall, but with some diffusing objects behind the speaker to break up the reflected energy. A highly absorbent rear wall defeats the purpose of a dipole; that reflected energy is beneficial, and you want to hear it. But if the wall is flat and lacks surfaces that scatter sound, the reflected energy combines with the direct sound in a way that reduces soundstage depth. Bookcases directly behind dipolar speakers help diffuse (scatter) the rear wave, as do rock fireplaces, furniture, and other objects of irregular shape. ASC Tube Traps can be positioned directly behind dipoles with their reflective sides out, or you can go all the way with RPG Diffusors. You still want to treat the sidewalls to absorb reflections with dipoles, but their narrow radiation pattern makes treating the sidewalls less important than with point-source speakers. This is particularly true of dipoles that sound their best toed-in toward the listening position. Similarly, dipoles have very narrow vertical dispersion, meaning they direct very little sound toward the ceiling and floor.

Dipolar loudspeakers also need to be placed farther out into the room than conventional point-source speakers. You can't put dipoles near the rear wall and expect a big, deep soundstage. Be prepared to give up a significant area of your listening room to dipolar speakers.

SUBWOOFER SETUP AND PLACEMENT

It's relatively easy to put a subwoofer into your system and hear more bass. What's difficult is making the subwoofer's bass integrate with the sound of your main speakers. Low bass as reproduced by a subwoofer's big cone can sound different from the bass reproduced by the smaller cones in the left and right speakers. A well-integrated subwoofer produces a seamless sound, no boomy thump, and natural reproduction of music. A poorly integrated subwoofer will sound thick, heavy, boomy, and unnatural, calling attention to the fact that you have smaller speakers reproducing the frequency spectrum from the midrange up, and a big subwoofer putting out low bass.

TIP

Don't put the subwoofer near a corner and equidistant from the side and rear walls.

Integrating a subwoofer into your system is challenging because the main speakers may have small cones, and the subwoofer has a large and heavy cone. Moreover, the subwoofer is optimized for putting out lots of low bass, not for reproducing detail. The main speakers' upper bass is quick, clean, and articulate. The subwoofer's bass is often slow and heavy.

Several controls found on most subwoofers help you integrate the sub into your system. One control lets you adjust the crossover frequency. This sets the frequency at which the transition between the subwoofer and the main speakers takes place. Frequencies below the crossover frequency are reproduced by the subwoofer; frequencies above the crossover frequency are reproduced by the main speakers. If you have small speakers that don't go very low in the bass and you set the crossover frequency too low, you'll get a "hole" in the frequency response. That is, there will be a narrow band of frequencies that aren't reproduced by the woofer or the main speakers.

Setting the subwoofer's crossover frequency too high also results in poor integration, but for a different reason. The big cone of a subwoofer is specially designed to reproduce low bass. When it is asked to also reproduce upper-bass frequencies, those upper-bass frequencies are less clear and distinct than if they were reproduced by the smaller main speakers. Finding just the right crossover frequency is the first step in achieving good integration. Most subwoofer owner's manuals include instructions for setting the crossover frequency. As a rule of thumb, the lower the subwoofer's crossover is set, the better, provided that there's no "hole" in the response described earlier.

Some subwoofers also provide a knob or switch marked Phase. To understand a subwoofer's phase control, visualize a sound wave being launched from your subwoofer and from your main speakers at the same time. Unless the main speakers and subwoofer are identical distances from your ears, those two sound waves will reach your ears at different times, or have a phase difference between them. In addition, the electronics inside a subwoofer can create a phase difference in the signal. The subwoofer's phase control lets you delay the wave generated by the subwoofer so that it lines up in time with the wave from the main speaker. When the sound waves are in-phase, you hear a more coherent and better-integrated sound.

One way of setting the phase control is to sit in the listening position with music playing through the system. Have a friend rotate the phase control (or flip the phase switch) until bass sounds smoothest.

But there's a much more precise way of setting the phase control that guarantees perfect phase alignment between the subwoofer and main speakers. First, reverse the connections on your main loudspeakers so that the black speaker wire goes to the speaker's red terminal, and the red speaker wire goes to the speaker's black terminal. Do this with both speakers. Now, from a test CD that includes pure test tones, select the track whose frequency is the same as the subwoofer's crossover frequency. Sit in the listening position and have a friend rotate the subwoofer's phase control until you hear the least amount of bass. The subwoofer's phase control is now set perfectly. Return your speaker connections to their previous (correct) positions: red to red, black to black.

Here's what's happening when you follow this procedure. By reversing the polarity of the main speakers, you're putting them out of phase with the subwoofer. When you play a test signal whose frequency is the same as the subwoofer's crossover point, both the sub and the main speakers will be reproducing that frequency. You'll hear minimum bass when the waves from the main speakers and subwoofers are maximally out of phase. That is, when the main speaker's cone is moving in, the subwoofer's cone is moving out. The two out-of-phase waves cancel each other, producing very little bass. Now, when you return your loudspeakers to their proper connection (putting them back in-phase with the subwoofer), they will be maximally in-phase with the subwoofer. This is the most accurate method of setting a subwoofer's phase control. Unless you move the subwoofer or main speakers, you need to perform this exercise only once. This technique works because it's easer to identify by ear the point of maximum bass cancellation (null) than the point of maximum bass reinforcement (peak).

The best integration comes from adding two (or more) subwoofers to your system. Two subwoofers drive the air in the room more uniformly, with fewer extremes of standing waves. The result is smoother bass throughout the room and better integration with the main speakers.

You can also get more dynamic impact and clarity from your subwoofer by placing it close to the listening position. Sitting near the subwoofer causes you to hear more of the sub's direct sound and less of the sound after it has been reflected around the room. You hear—and feel—more of the low-frequency wave launch, which adds to the visceral impact of owning a subwoofer. Bass impact is more startling, powerful, and dynamic when the subwoofer is placed near the listening position.

Subwoofer placement also has a large effect on how much bass you hear and how well the sub integrates with your main speakers. When a subwoofer is correctly positioned, the bass will be clean, tight, quick, and punchy. A well-located subwoofer will also produce a seamless sound between the sub and the front speakers; you won't hear the subwoofer as a separate speaker. A poorly positioned subwoofer will sound boomy, excessively heavy, thick, lacking detail, slow, and have little dynamic impact. In addition, you'll hear exactly where the front speakers leave off and the subwoofer takes over.

The most effective way of positioning a subwoofer is to put it near the listening position. Raise the subwoofer off the floor, if possible, so that it's close to where the listeners' ears would normally be. Play a piece of music with an ascending and descending bass line, such as a "walking" bass in straight-ahead jazz. Crawl around the floor on your hands and knees (make sure the neighbors aren't watching) until you find the spot where the bass sounds the smoothest, and where each bass note has about the same volume and clarity. Avoid positions where some notes "hang" longer, and/or sound slower or thicker, than others. When you've

TIP

Before spending money on upgrading components or acoustic treatments, be sure you've realized your system's potential with correct loudspeaker placement.

determined where the bass sounds best, put the subwoofer there. Now, when you're back in the listening seat, the bass should sound smooth and natural.

Some general guidelines for subwoofer placement: As with full-range speakers, avoid putting the subwoofer the same distance from two walls. For example, if you have a 20'-wide room, don't put the subwoofer 10' from each wall. Similarly, don't put the subwoofer near a corner and equidistant from the side and rear walls. Instead, stagger the distances to each wall. Staggering the subwoofer's distance from each wall smoothes the bass because the frequencies being reinforced by the wall are randomized rather than coincident.

MULTICHANNEL LOUDSPEAKER PLACEMENT

So far, we've discussed the placement of two loudspeakers for stereo music reproduction. With multichannel music and home theater becoming increasingly common, let's expand on these loudspeaker-placement principles to include positioning more than two loudspeakers.

The optimum loudspeaker type (point source, dipolar) and configuration differ for multichannel music reproduction and home theater. For multichannel music, the ideal loudspeaker array is five identical full-range loudspeakers placed equidistant from the listener. For film-soundtrack reproduction, the center loudspeaker is typically smaller and lacks bass extension, and the surround speakers are dipolar types mounted on the sidewalls. Loudspeaker arrays optimized for home theater also include a subwoofer.

> **TIP**
>
> **Dipolar loudspeakers need to be placed farther out into the room than conventional point-source speakers.**

Let's first look at the ideal multichannel music loudspeaker array. The center loudspeaker should be positioned on the room's center-line directly in front of the listening position, and slightly behind the plane of the left and right loudspeakers. This placement creates a gentle arc, and puts the center loudspeaker at the same distance from the listener as the left and right loudspeakers. If the three front loudspeakers were lined up, the sound from the center speaker would reach the listener before the sound from the left and right speakers.

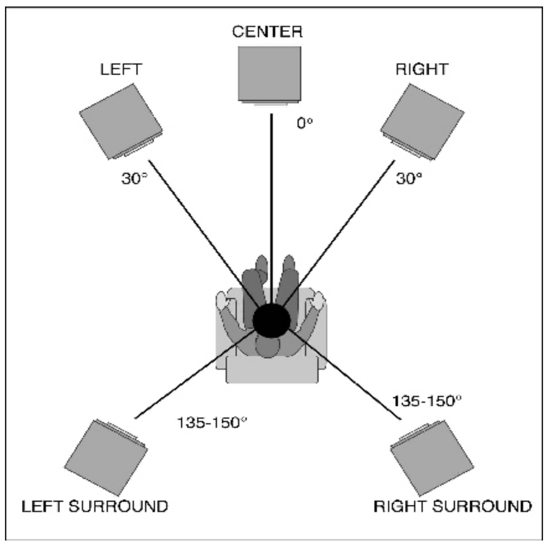


Fig.13 Optimum speaker placement for multichannel music reproduction.

The rear-channel speakers should be located at 135–150° as shown in Fig.13 and at the same distance from the listener as the front three loudspeakers. This placement isn't always practical, however, so many multichannel products provide a rear-channel delay for those situations in which the listener must sit closer to the rear loudspeakers. Delaying the signals to the rear channels causes the sound from the rear speakers to reach the listener at the same time as sound from the front speakers.

With this array, the front left and rear left loudspeakers can produce phantom images between them along the left sidewall, and the front right and rear right loudspeakers create phantom images along the right sidewall. Correct loudspeaker placement helps to achieve a soundfield that appears to be continuous from front to back, rather than as two separate soundfields at the front and rear of the room.

A multichannel music system can also employ seven speakers, with the two additional speakers located at the side positions. This array produces the greatest spatial realism because the side images are now "hard" rather than phantom, and the feeling of being immersed in a continuous soundfield is enhanced. Multichannel recordings made in a large acoustic and played back through a properly set up 7-channel system can be staggering in their ability to create a feeling of actually being inside the original acoustic space. It is even possible to hear discrete sidewall reflections localized along the sidewalls, just as one would hear at the original acoustic event.

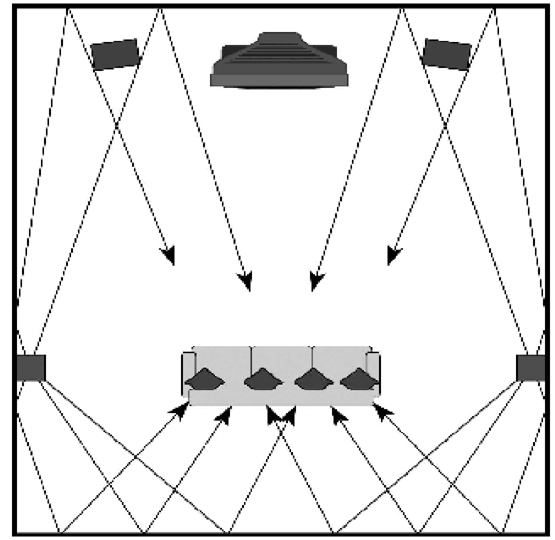


Fig.14 Multichannel speaker systems for film-soundtrack reproduction often use dipolar surround speakers located to the sides of the listening position.

Loudspeaker arrays optimized for film-soundtrack reproduction usually employ dipolar surround loudspeakers rather than point-source loudspeakers. Dipolar speakers produce sound equally to the front and rear; when positioned on the sidewalls, the listener hears sound from the surround speakers only after it has been reflected from the room's boundaries (Fig.14). This simulates the array of multiple surround speakers in a movie theater from just two surround speakers, and creates a greater envelopment.

LOUDSPEAKER PLACEMENT SUMMARY

Loudspeaker placement is the single most important thing you can do to improve your system's sound. It's free, helps develop listening skills, and can make the difference between mediocre and spectacular sound with the same electronics and loudspeakers. Before spending money on upgrading components or acoustic treatments, be sure you've realized your system's potential with correct loudspeaker placement.

After you've found the best loudspeaker placement, install the carpet-piercing spikes (if any) supplied by the manufacturer. Level the spikes so that the loudspeaker doesn't rock: the loudspeaker's weight should be carried by all four (or three) spikes. If you have wood floors that you don't want to mar with spikes, place the round metal discs that are often supplied with the loudspeakers beneath the spikes. If you have stand-mounted speakers, apply four small balls of Blu-Tack between the speaker and stand. This material, available in hardware stores for a few dollars, couples the speaker to the stand, making it sturdier and improving the sound.

You've seen how loudspeaker placement gives you precise and independent control over different aspects of the music presentation. You can control both the quantity and the quality of the bass by changing the loudspeakers' distances from the rear and sidewalls. The audibility of room resonance modes can be reduced by finding the best spots for the loudspeakers and listening chair. Treble balance can be adjusted by listening height and toe-in. The balance between soundstage focus and spaciousness is easily changed just by toeing-in the speakers. Soundstage depth can be increased by moving the speakers farther out into the room.

I've had the privilege of watching some of the world's greatest loudspeaker designers set up loudspeakers in my listening room for review. At the very highest levels of the art, tiny movements—half an inch, for example—can make the difference between very good and superlative sound. The process can take as little as two hours, or as long as three days. I've often had the experience of thinking the sound was excellent after half a day of moving the loudspeakers, only to discover that the loudspeaker was capable of much greater performance when perfectly dialed-in.

Loudspeaker positioning is a powerful tool for achieving the best sound in your listening room, and it doesn't cost a cent. Take advantage of it.

COMMON ROOM PROBLEMS AND HOW TO TREAT THEM

Treating your listening room can range from simply hanging a rug on a wall to installing specially designed acoustic devices. Large gains in sound quality can be realized just by adding—or moving—common domestic materials such as carpets, area rugs, and drapes. This approach is inexpensive, simple, and often more aesthetically pleasing than installing less familiar acoustic products. You can improve your room with existing household materials, or take the next step of installing dedicated acoustic-control devices. Here are some of the most common room problems, and how to correct them.

1) Untreated parallel surfaces

Perhaps the most common and pernicious of room problems is that of untreated parallel surfaces. If two reflective surfaces face each other, flutter echo will occur. Flutter echo is a "pinging" sound that remains after the direct sound has stopped. If you've ever been in an empty, uncarpeted house and clapped your hands, you've heard flutter echo. It sounds like a ringing that hangs in the air long after the clap has decayed. Flutter echo is a periodic repetition caused by the uncontrolled reflection of a sound back and forth between two surfaces. Imagine two mirrors facing each other, the reflections bouncing back and forth between the reflective surfaces to create the illusion of an infinitely receding distance. Flutter echo can blur transient attacks and decays and add a hard, metallic character to the upper midband and treble.

Try clapping your hands in various rooms of the house—particularly the bathroom or hallway. If your listening room has a pinging overhang similar to what you hear in the bathroom, you need to correct this problem.

Flutter echo is easy to prevent. Simply identify the reflective parallel surfaces and put an absorbing or diffusing material on one of them. This will break up the repeated reflections between the surfaces. The material could be a rug hung on a wall, a carpet on the floor (if the flutter echo is between a hard floor and ceiling), drapes over a window, or an acoustically absorbent material applied to a wall. Even small patches of highly absorbent acoustical foam, will kill flutter echo.

An effective material for controlling flutter echo without making the room too dead is a very thin carpet-like material used in airports and conference rooms. Although very expensive when sold as an acoustical treatment, this same carpet-like material is available from carpet mills for a fraction of the acoustic supply house's price. It is unobtrusive, easy to apply, available in a variety of colors, relatively inexpensive, and highly effective. Moreover, its absorption characteristics are just right for preventing flutter echo without absorbing too much energy and making the room "dead."

TIP

If you have wood floors that you don't want to mar with spikes, place the round metal discs that are often supplied with the loudspeakers beneath the spikes.

TIP

Fortunately, treating sidewall reflections is simple: Just put an absorbing or diffusing material on the sidewalls between the loudspeakers and the listening position.

2) Uncontrolled floor and sidewall reflections

It is inevitable that loudspeakers will be placed next to the room's sidewalls and near the floor. Sound from the loudspeakers reaches the listener directly, in addition to being reflected from the sidewalls, floor, and ceiling. Sidewall reflections are the music signal delayed in time, colored in timbre, and spatially positioned at different locations from the direct sound. All these factors can degrade sound quality. Moreover, floor and sidewall reflections interact with the direct sound to further color the music's tonal character. Fig.15 shows how the sound at the listening seat is a combination of direct and reflected sound.

Sidewall reflections color the music's tonal balance in three ways. First, virtually all loudspeakers' off-axis responses (frequency response measured at the side of the loudspeaker) are much less flat (accurate) than their on-axis responses. The sound emanating from the loudspeaker sides (the signal that reflects off the sidewall) may have large peaks and dips in its frequency response. When this colored signal is reflected from the sidewall to the listener, we hear this tonal coloration imposed on the music.

Second, the sidewall's acoustic characteristics will further color the reflection. If the wall absorbs high frequencies but not midband energy, the reflection will have even less treble.

Finally, when the direct and reflected sounds combine, the listener hears a combination of the direct sound from the loudspeaker and a slightly delayed version of the sound reflected from the sidewall. The delay is caused by the additional path-length difference between the sound source (the loudspeaker) and the listener. Because sound travels at 1130 feet per second, we can easily calculate the delay time. If the additional path-length difference in Fig.15 was 4', the sidewall reflection will be delayed by 3.5ms (3.5 milliseconds, or 3.5 thousandths of a second) in relation to the direct sound.

The result is a phenomenon called comb-filtering, a sequence of peaks and notches (hence its similarity to a comb) in the frequency response caused by constructive and destructive interference between the direct and reflected sounds. The phase difference between the two signals causes cancellation at certain frequencies and reinforcement at others, determined by the path-length distance. It all adds up to coloration of the signal at the listening position.

The result of these mechanisms—the loudspeaker's colored off-axis response, the sidewall's acoustic properties, and comb-filtering—is a sound with a very different tonal balance from that of the direct signal from the loudspeakers. Sidewall reflections are one reason the same loudspeakers sound different in different rooms.

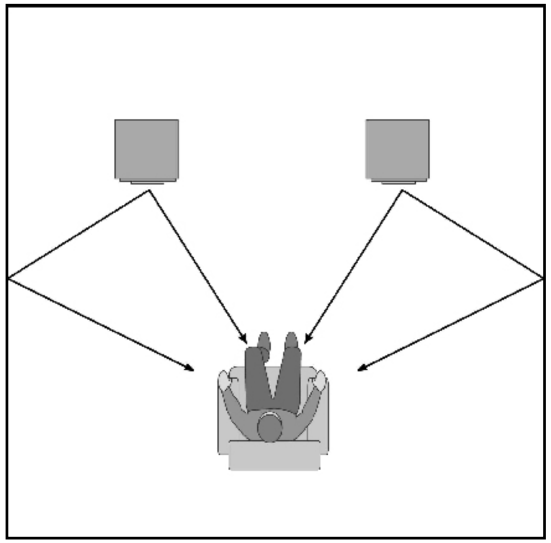


Fig.15 The sound at the listening seat is a combination of direct and reflected sound.

Sidewall reflections not only affect the perceived spectral balance, they also destroy precise image placement within the soundstage. The reflections present "virtual" images of the loudspeakers' signal that appear on the sidewalls. Although some degree of sidewall reflection adds spaciousness and size, strong reflections increase the apparent distance between the loudspeakers. This blurs the spatial distinction between individual images and makes the soundstage less focused and precise. When we hear a center-placed image as partially emanating from positions beyond the left and right loudspeaker boundaries, the tight image focus we seek is destroyed.

Sound also reflects from the floor and ceiling. Floor reflections tend to cause a reduction in midbass energy, making the presentation a little leaner. The ceiling reflection affects the sound less than the sidewall reflections because of its greater path-length difference. Note that the sound of dipolar loudspeakers, which direct very little energy toward the ceiling, is less affected by ceiling reflections than is the sound of conventional loudspeakers. Finally, a sloped ceiling is advantageous with conventional loudspeakers when those speakers are placed at the short end of the room. The ceiling slope will tend to direct ceiling reflections away from the listening position. Reflections reaching the listener from just one room boundary are called first-order reflections. These reflections have the greatest amplitude, and have the most effect on the reproduced sound.

Fortunately, treating sidewall reflections is simple: Just put an absorbing or diffusing material on the sidewalls between the loudspeakers and the listening position. Drapes are highly effective, particularly those with heavy materials and deep folds. The floor reflection is even easier to deal with: carpet or a heavy area rug on the floor will absorb most of the reflection and reduce its detrimental effects. Low frequencies, however, won't be absorbed by a carpet or rug, leading to a cancellation in the midbass caused by interference between the direct and reflected waves. This is the so-called

TIP

An open-backed bookcase full of books makes an excellent diffuser, particularly if the books are of different depths, or are arranged with their spines sticking out at different distances.

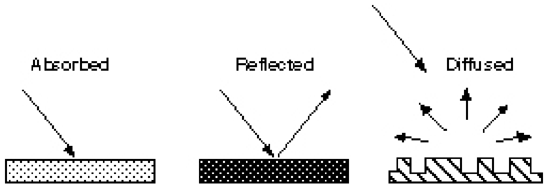


Fig.16 Sound striking a surface is either absorbed, reflected, or diffused (or a combination of all three).

"Allison Effect," named after loudspeaker designer Roy Allison, who first publicized the phenomenon.

Interestingly, the type of carpet between you and the loudspeakers can affect sound quality. Specifically, wool carpet produces a more natural tonal balance than does synthetic carpet. That's because the fibers in wool carpet all have slightly different lengths and thicknesses, which makes them absorb different frequencies. Synthetic carpet, by contrast, is composed of identically sized and shaped fibers that absorb only a very narrow band of frequencies. You can demonstrate this to yourself at a carpet store by speaking into sample pieces of wool and synthetic carpet and listening to the sound of your voice. The wool carpet will produce a more natural timbre.

Sidewall reflections should be diffused (scattered) or absorbed. Diffusion turns the single discrete reflection into many lower-amplitude reflections spread out over time and reflected in different directions (see Fig. 16). Diffusion can be achieved with specialized acoustic diffusers such as those made by RPG Diffusors, or an irregular surface. An open-backed bookcase full of books makes an excellent diffuser, particularly if the books are of different depths, or are arranged with their spines sticking out at different distances.

The second option is to absorb the sidewall reflection with an acoustically absorbent material. Specialty acoustic foams will work, but completely absorbing the sidewall reflection with an aggressive foam can make the room sound lifeless and constrict the presentation's sense of size and space.

There is some debate in the high-end community as to whether sidewall reflections should be absorbed or diffused. Diffusion proponents argue that the reflected energy is beneficial if converted to many lower-amplitude reflections spread out over time and space, the diffused reflections increasing the presentation's spaciousness and air. Absorption proponents suggest that any reflections within the first 20ms of the direct sound degrade the signal from the loudspeakers. Most recording-studio control rooms are designed to provide a "Reflection Free Zone" (RFZ) where the engineer sits, so that he or she hears only the direct sound from the studio monitors. My experience suggests that absorbing sidewall reflections is better than diffusing them, but that diffusing materials behind the listening seat are better than absorbing materials. Diffusing sidewall reflections tends to increase the spaciousness of the sound; absorbing sidewall reflections reduces soundstage width, but results in tighter image focus and a more spatially coherent presentation. There is no debate, however, about whether or not uncontrolled sidewall reflections degrade a room's sonic performance. They do.

An excellent product for controlling sidewall reflections is the Tower Trap, also made by the Acoustic Sciences Corporation. This is a tall, cylindrical device with absorptive and reflective (diffusive) sides. Absorption or diffusion can be selected simply by turning the device. When placed near the sidewall with the reflective side to the room rear, the absorptive side prevents the first reflection from reaching the listener directly. Some of the energy striking the sidewall is reflected into the Tower Trap's rear (diffusive) side. Most of the sidewall reflection is absorbed, while some is delayed in time, attenuated, and diffused—exactly what we want.

Note that it isn't necessary to treat a listening room's entire sidewall area; the reflections come only from small points along the wall. At mid- and high frequencies, sound waves behave more like rays of light. We can thus trace sidewall reflections to the listening seat and put the treatment in exactly the right location. As with light rays, a sound wave's angle of incidence equals its angle of reflection. That is, the angle at which a sound wave strikes a reflective surface is the same as the angle at which it bounces off that surface.

The technique for tracing sidewall reflections is shown in the series of photographs and illustrations in Figs.17, 18, and 19. First, mount a reflective Mylar strip on the sidewall between the listener and the loudspeaker. The strip's center should be at the height of your ears when you're sitting in the listening chair. Next, put light sources (two lamps with their shades removed is ideal) where the loudspeakers are normally placed, as shown in Fig.17. When sitting in the listening chair, you'll see the two lamps reflected in the Mylar strip (Fig.18). The points along the Mylar strip where you see the lamps' bulbs are exactly the points where sound is reflected from the sidewalls to the listening seat. This is where to put the acoustic treatment. The photograph in Fig.19 shows how strategically placed acoustical materials (in this case, ASC Tower Traps) can kill sidewall reflections from both loudspeakers. Compare Fig.18 to Fig.19.

Repeat the process for the left sidewall. If your listening room is symmetrical and the listening position is in the middle of the room, you need use this technique on only one sidewall, then duplicate the acoustic treatment on the other. To maintain acoustical symmetry in the room, both sidewall treatments should be the same.

Treating the sidewall reflections from both loudspeakers on each sidewall improves imaging. The right sidewall will reflect sound from both right and left loudspeakers. The reflection of the left loudspeaker's signal from the right sidewall confuses image placement and constricts soundstage width. This reflection can be thought of as a kind of "acoustic crosstalk"; we don't want left-channel information reflecting from the sidewall into the right ear.

Note that a treatment placed away from the wall creates a larger apparent surface area than a treatment attached to the wall. The distance between the treatment and the wall causes the treatment to cast an acoustic shadow on the wall, widening the effective absorption area.

This technique can be applied to all reflections in the listening room. If you put a Mylar strip around the entire listening room, any point where you see a reflection of the light bulb itself is also a sound-reflection point. Additional absorptive or diffusive surfaces can then be placed and oriented exactly where they do the most good. You can also simply sit in the listening position and have a friend move a mirror along the sidewall. The point where you see the speaker's drivers in the mirror is the point where you should position absorbing or diffusing materials. This technique works for floor reflections; the point on the floor at which the mirror reflects the tweeter to the listening position is the place to add absorbing material.

Even if you don't go to the trouble of putting up a Mylar strip and lamps, you should do something to treat sidewall reflections. Bookcases, rugs, and drapes are all better than bare walls. If you really want to get the best from your system, however, there's no substitute for professionally designed acoustic treatments.

TIP

Treating the sidewall reflections from both loudspeakers on each sidewall improves imaging.

3) Thick, boomy bass

Thick, boomy bass is a common affliction that can be difficult to control. It often results from room resonance modes, poor loudspeaker placement, poor loudspeakers, or not enough low-frequency absorption in the listening room. As we will see in the later section on standing waves, listening-seat position can also exacerbate bass bloat.

If thick and boomy bass persists even after minimizing it with careful loudspeaker placement (the most effective method of alleviating the problem), you may want to consider different loudspeakers. If, however, the boominess is minor and you want to keep your loudspeakers, you can make the presentation leaner and tighter by adding low-frequency absorbers. These devices soak up low frequencies rather than reflecting them back into the room.

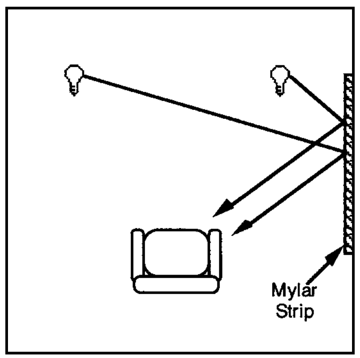


Fig.17 A simple trick for finding the sidewall's first-reflection points.

Passive low-frequency absorbers simply convert acoustic energy into another form—usually heat within a fibrous material. Low-frequency absorbers can be bought ready-made (such as ASC's Tube Traps and Tower Traps), built from common materials, or incorporated into an existing room structure. The easiest and most effective low-frequency absorber for the audiophile is ASC's 16" Full Round Tube Trap. These devices are extremely powerful, soaking up bass below 125Hz—the region below which most domestic materials stop absorbing. A pair of 16" Full Round Tube Traps in the corners behind the loudspeakers significantly tightens up the bass and removes boom and bloat. Tube Traps employ a plastic sheet beneath the fabric exterior that covers about half the Trap. By rotating the trap, you can adjust the amount of high- and mid-frequency absorption; with the reflective side facing the listener, the Trap acts as a mid- and high-frequency diffuser. With the reflective side facing the wall, the Trap absorbs a broader range of frequencies. This variability is useful when tuning a room; rotating the Traps so that the reflective side faces the listener keeps the sound from becoming overdamped in the midrange and treble.

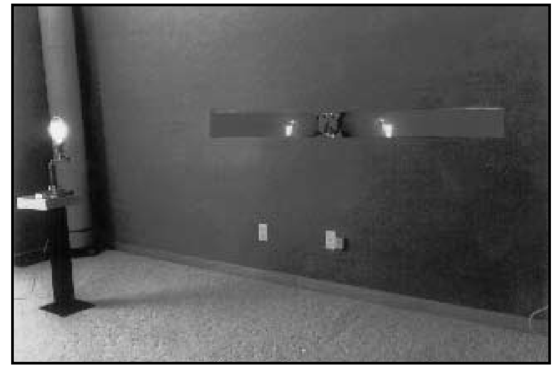


Fig.18 The points of visual reflection are also the points of acoustic reflection.

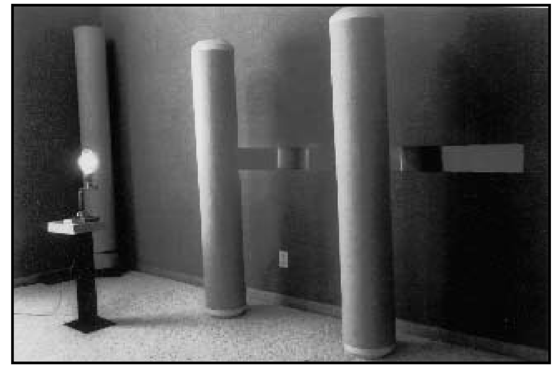


Fig. 19 Absorbing or diffusing materials at the first-reflection points greatly increases sound quality.

ADDENDUM: ADDING HOME THEATER WITHOUT COMPROMISING MUSIC PERFORMANCE

Many readers will have multichannel systems that serve as both a stereo music system and a multichannel music or multichannel home-theater system. This addendum describes how to configure such a system in a way that delivers uncompromised stereo music performance.

As Editor-in-Chief of *The Absolute Sound* and *The Perfect Vision* magazines (the latter for six years until late 2006), my job involves evaluating cutting-edge, state-of-the-art 2-channel audio products as well as high-performance home-theater components. Clearly, the performance of my 2-channel system cannot be compromised by the presence of home-theater products. Here's what I've done to integrate home theater into my music-playback system.

First, my video display is a front-projection system with a retractable, motorized screen. The projector is at the back of the room, and when I listen to music, the screen is rolled up into a small enclosure. With the screen in the lowered position, soundstage depth is compromised, as is the precision of image placement. If you use a front projector, a motorized screen's ability to retract for music listening is a big benefit.

If you must use a fixed screen, drapes that can be drawn across the screen when you play music are effective at preventing the screen from reflecting sound. Those who use a flat-panel television or rear-projector big-screen are faced with the challenge of having a large, acoustically reflective object near the loudspeakers.

As described earlier, absorbing acoustic reflections at the loudspeaker-end of the room is important. To minimize the television's degradation of the sound, move the television back as far as possible, and bring the left and right loudspeakers forward.

One system configuration is to use an audio/video controller that also performs the functions of a traditional stereo preamplifier. In this system, all your source components (CD, DVD player, music server, turntable, etc.) connect to your controller. A important feature on the controller is called "analog bypass." This feature passes analog input signals through the controller without converting the signal to digital and then back to analog.

Keep in mind, however, that even the very best multichannel controllers fall short of the performance standards set by high-end 2-channel preamplifiers, even in analog-bypass mode. If you want uncompromised musical performance, you'll need a controller and a separate 2-channel preamplifier. The preamplifier should have a "theater pass-through" mode that sets one of the inputs at unity gain (the output signal's amplitude is the same as the input signal). The left and right outputs from your controller drive this unity-gain input, and the preamplifier is connected to the power amplifier in the usual way. When watching movies, it's as though your preamp isn't there. When listening to music, it's as though your controller isn't there. With this technique, your analog sources never go through the controller.

Robert Harley, Editor-in-Chief of *The Absolute Sound* magazine, has written more than 800 equipment reviews and articles on high-quality music reproduction. His books *The Complete Guide to High-End Audio, Introductory Guide to High-Performance Audio Systems,* and *Home Theater for Everyone* have sold more than 150,000 copies in four languages. Robert holds a degree in recording engineering, and has worked as a recording engineer, CD mastering engineer, college teacher (a degree program in audio engineering), and audio journalist.