SPEAKERS & AUDIO MONITOR

Proper placement and adjustment are the key to accurate sound reproduction.

BY CHRISTOPHE ANET

A monitoring system should reproduce sound without adding or taking anything away from the original input signal. Human hearing features a phenomenon called auditory masking, and modern recording systems have a flat electronic frequency response. To accurately monitor what is recorded, mixed-down or broadcasted, the monitoring system must also have a flat response at the listening position.

However, monitors are built in anechoic conditions, and their response changes when placed into a listening room because of room boundary loading, reflections, reverberation time characteristics, etc. Precise adjustment of the monitor's response is needed for optimal loudspeaker-room interaction and flat frequency response at the listening position.

The multichannel audio control room shown here features flush-mounted stereo main monitors as well as a 5.1 surround system setup according to the ITU-R BS.775-1 standard. Note that the free-standing front left-center-right monitors are placed on separate stands to avoid vibration coupling between the console and the enclosures. The rear monitors are flush mounted in the side wall structure. Photo courtesy of WSDG Architecture and Acoustic Design.

Common mistakes

Most audible problems occur because of the effects of the room acoustics. Many control rooms use a combination of loudspeakers, subwoofer and bass management to reproduce six or more discrete channels. Because all loudspeakers and subwoofers are omnidirectional at low frequencies (below 200Hz), cancellation effects, room standing waves and the proximity of boundaries will affect the loudspeakers/subwoofer performance.

When a loudspeaker with flat anechoic (4π) response is placed against one solid boundary (large compared with the wavelength), the radiation space becomes 2π, and the theoretical amplitude gain is 6dB for frequencies below a few hundred hertz. This applies to flush-mounted loudspeakers or loudspeakers placed with their back against a solid, hard wall. In all cases, this amplitude change has to be compensated to retrieve a flat and neutral frequency balance. (See Figure 1.)

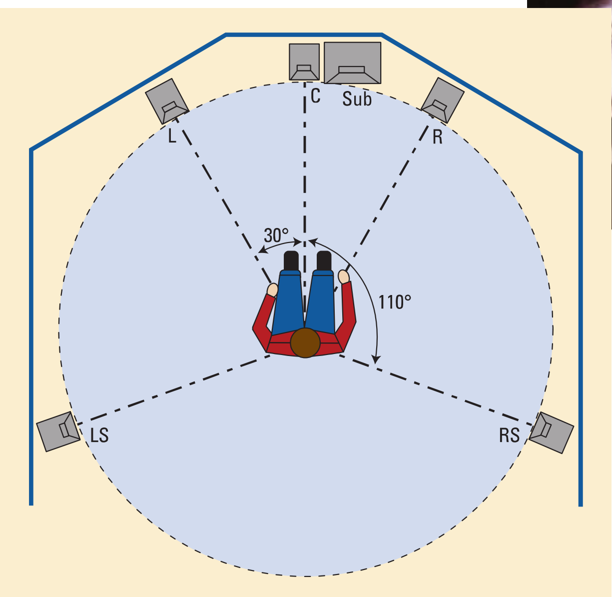

Figure 1. ITU-R BS.775-1 speaker placement with each main speaker placed against a wall (hemispherical loading)

Typical subwoofer location is on the floor and against a wall. These two large boundaries (radiation space π) cause a +12dB amplitude gain compared with free field. This gain is beneficial, as it provides additional headroom and less distortion. If a subwoofer is placed in a room corner, the radiation space is further halved, and the amplitude gain becomes +18dB. Adjustments of such a system can become difficult due to strong modes excitation from the room corners. Placing the subwoofer slightly offset from the central axis of the room is often beneficial as it allows the subwoofer to radiate energy away from pressure minima and maxima.

The wall behind the loudspeaker cancellation is another interference generated by the single reflection from a hard wall behind the loudspeaker. When two identical signals are in antiphase, they cancel each other. If the loudspeaker is a quarter wavelength away from a reflective wall, the reflected wave comes back to the loudspeaker with half a cycle phase difference and thus cancels the original signal at that frequency. The importance of the cancellation depends on the distance and the reflection coefficient of the wall, but it is usually well audible.

Proper placement

When cancellation occurs in a monitoring system using an 85Hz crossover between loudspeakers and subwoofer, there is a set of practical placement solutions. (See Figure 2.) First, the distance between the radiating subwoofer driver and the wall providing part of the low frequency loading must not exceed a conservative 60cm. If the subwoofer (driver) is placed further, cancellation and comb filtering will start to occur below

85Hz, degrading the subwoofer response. Satellite loudspeakers high-passed at 85Hz do not have to reproduce very low frequencies, so they may be placed at a distance where low frequency notches do not occur in their passband. Here are three practical placement alternatives:

- Loudspeakers can be flush-mounted in a hard wall (or infinite baffle), eliminating rear wall reflection. With two-way loudspeakers, this option is rarely implemented but is almost inevitable with large fullband monitors.
- Place the loudspeaker very close to the wall, increasing the cancellation frequency. (With very small loudspeakers, which are inherently less directional in mid frequencies, the dip just moves to the low midband and might cause even worse coloration.) In most cases, distances between 0cm and 20cm between the front radiating driver and the wall behind can be considered as safe. (The directivity of the loudspeaker should be high enough so the rear radiation cannot cause a severe cancellation.)

Despite accurate subwoofer phase control adjustments, avoid placing satellite loudspeakers further than 2m away from the subwoofer. The tonal balance between the loudspeakers and the subwoofer may differ considerably due to excitation of different room modes by the sources.

The acoustical adjustment of the interaction between loudspeakers and room is important before doing any kind of level calibration. The frequency response of the complete monitoring system should be consistent across the entire spectrum without cancellation dips.

Room acoustics

Ideally the control room environment should be symmetrical, and the listening path should be clear of any equipment that might cause interfering reflections. Interference of first (or higher) order reflections affects a loudspeaker's response at the listening position. For the human ear, imaging is lost as soon as the delayed signal arrives in a suitable time window and from an acceptable direction in relation to the direct sound (Haas and precedence effects).

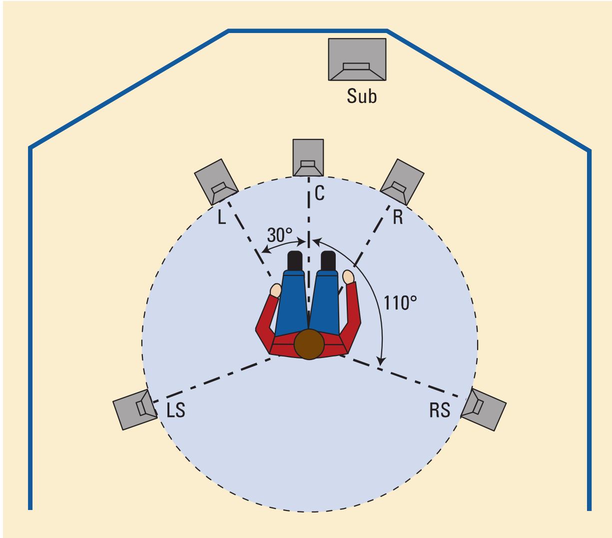

Figure 2. ITU-R BS.775-1 speaker placement with each main speaker placed at least 1.1m from the wall behind

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- Move the loudspeaker away from the wall up to 1.1m, causing the cancellation frequency to go below the 85Hz cutoff of each satellite loudspeaker. From 1.1m to 2m, loudspeakers may be placed without serious cancellation compromises. Distances to other room boundaries become smaller, and reflections from these other surfaces might start to dominate the response.

High amplitude, early reflections can smear the coherence of the spatial information and compromise sound source localization. To avoid this, all reflecting surfaces (racks, computer tables, etc.) placed between the loudspeakers and the listening position should be removed, or at least minimized. All tables and outboard racks placed close to the listening area should be lower than the typical mixing console height. With DAWs, the insertion of large screens into the work surface will significantly reduce first order reflections from the center loudspeaker. Perforated tabletops can also further reduce such reflections. However small the remaining surfaces may be, reflections in the time domain should be identical from both the left and right half of the room. Furniture could be designed so that there are no additional surfaces beyond the job needs.

For the placement of the listening position in the room, research indicates that the reference point be located in the front half of the room so that the engineer benefits from the best direct-to-reverberant sound ratio. In the presence of rear loudspeakers, the acoustic design of the front half of the room becomes more complicated. If the room has hard and reflective front wall surfaces, direct sound from the rear left loudspeaker will bounce on the front right loudspeaker and nearby boundaries. This situation should be avoided, as these strong first reflections will alter the front loudspeaker's direct sound. This calls for some planning in room geometry and adequate location of absorptive surfaces in the mid- and high-frequency band. BE

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