

Approaches To Live Surround

Looking at the logical evolution

By Michael Miles

The design of a concert sound system, especially for stereo sound, requires close attention to issues such as room acoustics, headroom, loudspeaker levels, timing, and coverage. For a surround system, those basic issues are even more important and complex.

This is because the timing and level distribution of the sound are dependent on the direction of wave propagation. Mono and stereo sound can propagate generally from the stage toward the more distant part of the audience, where the level may decrease and the delay will increase. But in surround sound, wave propagation occurs in various opposite directions, therefore the level balancing and synchronization of loudspeakers across the audience is more difficult.

There are distinct types of surround systems suitable for different applications. For example, an ambience surround system may provide additional room sound (reverberation and early reflections) for improving the room response or to change its "liveness" for a particular performance.

Cinema surround systems typically provide left-center-right (LCR) for front localization, and additional channels to cover the sides and rear. Since the sides and rear surround channels are primarily used for sound envelopment and effects, the problems with varying delay from multiple sources are not very noticeable.

A music surround system, in contrast, needs better time alignment between all of the audible sources. In addition, the surround loudspeakers will need to match the main loudspeakers' frequency response and headroom. Let's look at conceptual approaches to creating this type of system in venues that are too large for conventional loudspeaker layouts.

ANY AUDIBLE EXPERIENCE

One of the most convincing sound reproduction methods is binaural. When implemented to the fullest, this method is capable of accurately creating or recreating just about any audible experience. But among other things, it requires the signals heard by the left and right ears to be kept separate. Headphones can provide total separation but their use by a large audience is usually not very practical or desirable.

The unwanted interaural crosstalk that occurs when speakers are used can be canceled with digital processing, but this is only practical for a specific listener at a specific location. Even then, it can only be an approximation that is not likely to perform well for side or rear directions, and cannot tolerate much listener movement. For a large audience, this method is not yet practical, although holding great potential, it may become viable in the future.

The precise reconstruction of any sound wave from a group of loudspeakers is possible, but only at a single point in space. An "Ambisonic" system achieves this using a mathematically correct operation to create each loudspeaker's drive signal based on its location with respect to the listening point. If the angular spacing between adjacent loudspeakers is not too large, this approach can work quite well.

But for a listener who is some dis-

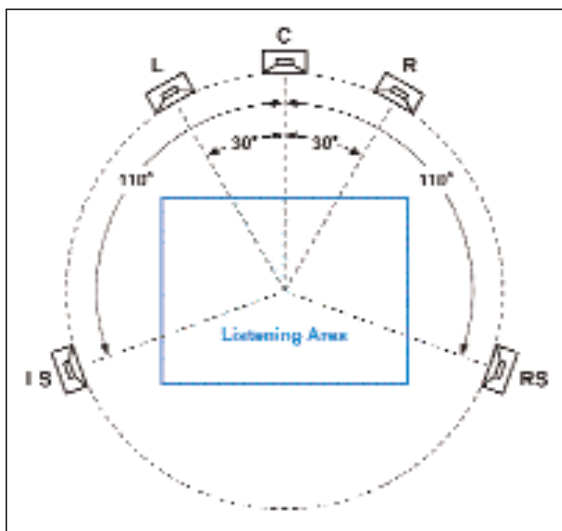


Figure 1: The recommended layout for a 5.1 listening room. This provides good time alignment but a small listening area.

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tance from the ideal point, neither the mathematical process nor the listening experience is optimum. For significantly off-center listeners, there are other methods that can provide a better surround experience, primarily by virtue of higher channel separation allowing clearer perception of opposite-side sound-source locations.

A practical approach to sound staging used in cinema and live theater is placing loudspeakers in specific desired locations and simply assigning the signal to them as needed. This is particularly effective in theatrical productions, where certain sounds require precise point-source localization for a very wide audience area, and loudspeakers can be arbitrarily placed.

When a wide, full sound stage is needed, pair-wise panning can produce effective localization if enough loudspeakers are used to minimize the angle between them. Computer-controlled routing and panning systems are available and especially useful for complex layouts with many loudspeakers.

Panning works well if the loudspeaker layout is optimized and the audience area is not too wide for it. For electronic sources, it's usually the simplest available method for creating a wide, spatially interesting sound. Therefore it's useful for a system layout to accommodate both panned sources and individual discrete sources.

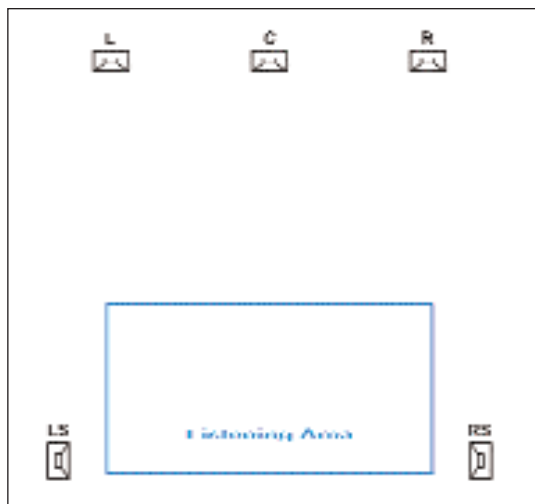


Figure 2: Dolby recommends this home theater layout. The surround loudspeakers are to be 3 feet above the listeners, and the linear LCR layout increases the size of the listening area.

Because most audio recordings are made with pair-wise panning, the usual recommendation for a home audio system accommodates this type of program source. For good performance, adjacent loudspeaker channels subtend a small angle (less than 45 degrees) from the listener's vantage point, and are in close time alignment with each other.

CENTRAL LISTENING AREA

The recommended loudspeaker layout for 5.1 systems, shown in **Figure 1** (previous page), is time-aligned and optimized for music, but it has a small central listening area. And while the two rear loudspeakers can work nicely as discrete sources, surround panning will not work well because the angle between these loudspeakers is too large.

For group listening and viewing, Dolby recommends the layout shown in **Figure 2**. This arrangement allows for an increased listening area with a small tradeoff in time alignment, and the use of a diffused surround field.

Expanding this to a larger room yields the typical commercial cinema arrangement shown in **Figure 3**. Note that additional surround loudspeakers provide more even sound distribution, satisfying the goal of envelopment, and allowing audible but imprecise effect panning in the surrounds.

A versatile, high-performance surround system for music will require more loudspeaker channels for the sides and rear. A left-center-right rear array makes a significant improvement, and if the budget and space permits, side channels could feasibly complete a horizontal-plane surround system.

The use of eight channels with 45 degrees between adjacent channels yields good performance with program sources incorporating pair-wise panning.

Since we can't change the velocity of sound in air, the only way to eliminate excess differential delay problems in a large venue is to keep the loudspeakers

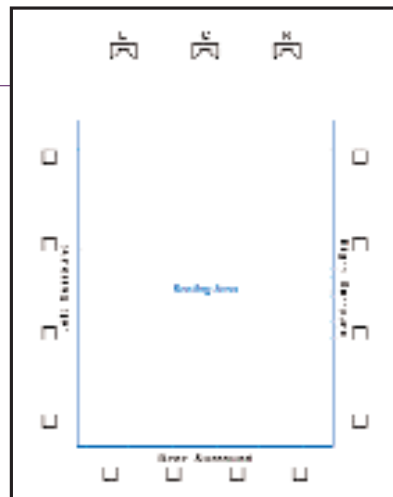


Figure 3: This layout is typically used in commercial cinemas. The listening area is large but surround performance may be compromised by the use of multiple overlapping sources.

near enough to the listeners. Having significant overall propagation delay to the furthest seats from the stage is usually not a problem. People are accustomed to that, as long as the sound seems to originate at the stage.

Therefore a large system that provides good surround sound, in addition to good stereo stage sound, can be made with a combination of a multi-channel front array and a distributed loudspeaker system with coverage across the audience.

A LCR main stereo system above the stage is a good start, and a variety of well-documented ancillary techniques can be used to enhance its performance. These include utilizing multiple additional loudspeakers as delayed fills to enhance coverage of the rear portion of the audience. With correct level and delay settings, these will add loudness without degrading the clarity and localization of sound from the more distant main loudspeakers. A mono mix of the front program material can be used to drive the delayed fills.

ZONING CONSIDERATIONS

The basic problem with surround in a large venue is that there is too much delay between the front and rear of the audience area. To accommodate this, the audience area can be divided into sections that are small enough that a tolerable propagation delay spans them – perhaps 30 to 40 feet across. These areas are then individually covered with loudspeakers behind and

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above each area.

The loudspeakers will need good directivity control to minimize leakage to adjacent areas, and each will need its delay adjusted to properly synchronize its sound field with the main loudspeakers. A possible implementation is shown in **Figure 4** and **Figure 5**. All of the loudspeakers depicted need to be high enough above the audience to provide reasonably even coverage.

The delayed fill (DF) loudspeakers are fed with a mono mix of the front (LCR) channels, and delayed electronically so that their sound arrives to the listeners in the back just slightly later than the sound from the actual front loudspeakers. The levels are set low enough so that front localization is not disrupted.

In **Figure 4**, the front-zone loudspeakers LS1, CS1, and RS1 may need little or no delay. They should synchronize with the front loudspeakers at the center of the zone they cover. The rear-zone loudspeakers LS2, CS2, and RS2 will need delay to synchronize with the front loudspeakers at the center of the rear zones. In the

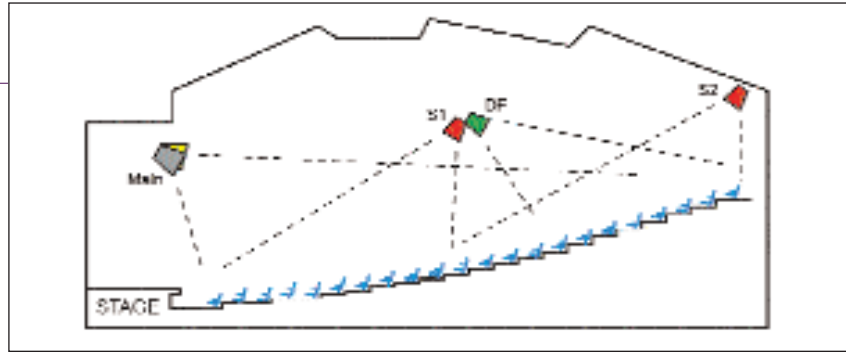


Figure 5: Side view of distributed surround layout. Loudspeaker "DF" is a delayed fill supporting the main system.

example shown this would likely be in the range of 45 to 60 milliseconds.

This concept uses a conventional left-center-right layout for front sound staging covering the entire venue, and provides individual surround performance to smaller groups of the audience so that front-to-rear timing is manageable. For larger venues, more surround zones will be needed. The size of each zone cannot be increased without seriously degrading the front-to-rear time alignment.

A good surround system can provide a sense of immersion in the sound field, and can simultaneously allow specific sounds to arrive from many various directions around the listener, as

determined by the program mix. The possibilities of spatial sound staging enjoyed by conventional left-right stereo can be expanded to all directions in a horizontal plane above the listeners. With a bit more equipment, overhead sounds could be added as well for a more complete audio experience.

Before using a live surround system, one needs to know the requirements of the performance, and how the sound should be spatially presented. This may depend on the desires of the composer, performer, producer, and/or the mix engineer. Then the appropriate loudspeaker utilization and drive scheme can be determined.

GOOD FRONT SOUND

Many think of "5.1" when they think surround. But five-channel sound was developed for cinema applications and recording media with a limited number of channels. Fortunately, it incorporates the LCR front loudspeaker arrangement that is usually the best way to provide good front sound staging.

But for live surround sound, one only needs to address the geometry of the venue without concern about conventional layout standards, recording formats, or recording media limitations. Additional mixer outputs can be set up to drive individual loudspeaker feeds as needed. Signal routing can be established to meet the directionality needs of the program material, which may call for six, eight, or more surround channels.

Although panning a sound between adjacent channels is a convenient method of routing, and is offered by virtually all mixing consoles, it is not necessarily the best method for every source. With acoustic music, especially with a group of performers, one can use multiple microphones and route

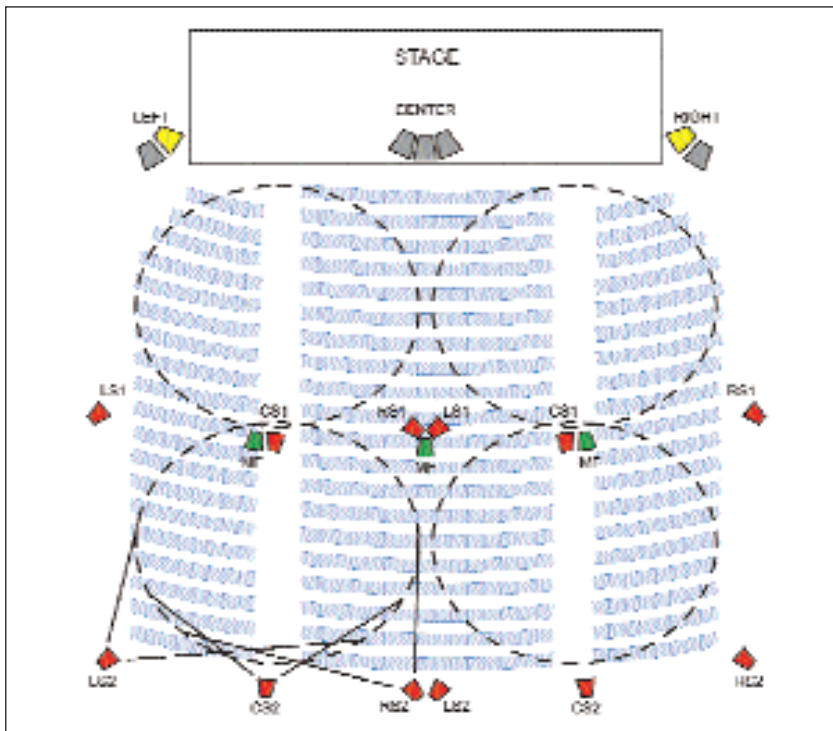


Figure 4: Proposed distributed surround layout. The audience area is divided into four smaller surround zones to minimize the effect of excess delay.

them to individual loudspeakers or output channels. This method produces low correlation and natural delay between the channels, resulting in improved spaciousness, more transparency, and better clarity.

There is debate among some regarding the necessity of maintaining stereo separation into the low bass frequency range. In the case of surround sound, this multiplies the amount of equipment while reducing its utilization. As with home theater, good results are possible using just one or two front subwoofer channels if they are crossed over at a low enough frequency. This should be a viable option when budget or physical constraints dictate, and even if they don't, good coverage of the audience may be a higher priority than directional bass.

The rewards of surround sound music can be great. As with cinema, a surround sound concert system allows a more dramatic and entertaining show. The additional output channels, loudspeakers, and spatial sound distribution yield more dynamic impact without excessive loudness.

In addition, as more artists incorporate surround sound into their performances, the demand for this type of sound system will increase. The technology seems to be largely driven by the production of surround DVDs, and the gradual realization that surround channels are not just for reverb and applause. The increasing popularity of surround sound music for home playback should lead to increased use of surround sound at live concerts.

Although this may seem backward, it's a practical reality that excellent surround sound can be recorded on a disk for playback at home, while the use of surround at a live concert is a relatively complex and expensive proposition. But just as stereo sound has mostly replaced mono, it's logical that in the future surround capability will see increasing use in live concerts. ■

Michael Miles has two decades of product and system design experience, and is the founder of Miles Technology, a provider of professional multichannel audio products. He holds an Electrical Engineering degree from the University of Michigan, and can be reached at mike@milestech.com

butterfly...
Perfectly Simple

Source: Butterfly System White Paper by G. Leo Basso

D.P.R.W.G.
Double Parabolic Reflective Wave Guide (*)

Single Hi-Pack element features:

- Volume = 0.087 m³
- Weight (including flying hardware) = 85 kg / 77 lb.
- Number of speakers = 5
- Centre-to-centre step = 0.243 m / 9.5 in.
- Continuous power = 920 W RMS (AES Standard)
- Max SPL (peak) 1 m = 140 dB

16-element Hi-Pack array features:

- Max. array height (straight array) = 3.89 m / 12.8 ft.
- Total weight (including flying frame) = 620 kg / 1,365 lb.

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