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WHY SURROUND SYSTEMS *STILL* DON'T WORK

BY

JOHN F. ALLEN

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WHY SURROUND SYSTEMS *STILL* DON'T WORK

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Non theatrical options for viewing motion pictures keep getting better. Sales of home theatre systems remain strong while attendance at movie theatres stays flat, at best, or drops. According to Reuters/Variety, sales of DVD players in the first half of this year were 70 percent ahead of 2000 with 5.2 million DVD players sold. Shipments of these players is expected to top another 10 million in the second half of 2001. As of midsummer 2001, more than 20 percent of US households now enjoy this advanced format when watching films at home. More than 80 million DVD movies and music-video titles were reportedly shipped to retailers in the second quarter this year, nearly 2 1/2 times the number of units shipped in the same period last year.

Of course, one of the major improvements made available by the DVD is the sound. Indeed, DVD equipped home viewers can now enjoy the same (or better) 6 channels of digital sound now playing in most first run theatres. It should also come as no surprise that after years of scrimping on theatre sound systems, it has become fairly easy for even a modest home theatre sound system to sound better than a real theatre. This is especially true of the surrounds due to the number of home packages with matched speakers now on the market.

This need not be the case. Indeed, if exhibitors wish to see their market expand, it cannot be the case!

In 1983, I wrote an article for this magazine explaining the reasons why the vast majority of the arrays of surround speakers installed in most movie theatres failed to provide the surrounding effect they were allegedly designed to produce. Now, some 18 years later, the situation remains much the same. Audiences are routinely deprived of the enjoyment, enrichment and amazement that a good surround system can deliver. Today this is even more of a loss for all concerned because the surround tracks of contemporary films are often so much more active and engrossing.

Gone are the days when surround speakers were simply thought of by producers and mixers as an array of inexpensive "effects" speakers dotted around the theatre. Modern digital soundtracks are created with the assumption that the combined surround channels are to be treated as equal to a screen channel in both frequency range and, more challenging, dynamic range. Such recordings demand that surround speakers be very high quality and high output devices. The layout of these speakers is also extremely important as they must be able to reproduce BOTH ambiance effects (soft wind or music reverberation) as well as highly directional effects such as flyovers and ricocheting bullets. All this must be done without any single speaker within the surround array calling attention to itself.

Such demands are not easily met. Indeed, the admonition I wrote 18 years ago remains as true today as ever -- that virtually every mistake one could possibly make is commonplace when it comes to the design and implementation of surround systems. The surround speakers we are likely to encounter in movie theatres are typically too small, too inefficient, too underpowered and poorly placed. With the now regular use of equalization in the surround channels, the systems are also most likely to be wildly over-equalized. As a result, the majority of movie patrons fail to experience a sense of being surrounded by anything. Rather, the surround speaker nearest to them tends to dominate over the others. What's more, due to the poor quality of the sound ultimately emanating from the speaker(s), very little may be heard at all. The result is that the soundtrack for the film remains largely a screen event, with only a whisper to, even worse, a distraction occasionally coming from the surrounds.

To illustrate this, I compared the surround array coverage and performance in two theatres of identical size. I will call them theatre "A" and theatre "B." When one listened the surround quality in these two theatres, it became immediately apparent that the 10 surround speakers in theatre "A" provided vastly superior coverage, tone and overall performance as did the 14 surround speakers in theatre "B." Indeed, this was the unanimous conclusion of all who heard and compared these two systems with the same films. How could this be when the conventional wisdom is that the more surround speakers there are, the better the surround effect will be? There are several reasons.

The speakers placed around theatre "B" were two way, each employing a 12 inch woofer and a 1.5 inch tweeter attached to a wave-guide for coverage control. The surround speakers in theatre "A" were three-way with a 12 inch woofer as well as horn loaded midrange and tweeter sections. As the industry has finally moved from two-way to three-way screen speakers, it is puzzling that the surround speakers have not been upgraded to three-way at the same time. The lower distortion and superior sound quality available

from well designed three-way surround speakers dramatically improves the sound from the surrounds. It is an unfortunate truth that the worst sounding speaker in a sound system determines the sound quality appreciated from all the speakers in the system. The tone of the surround speakers should match the tone from the screen speakers. This demands an end to the time honored tradition in this industry of scrimping on the surround speakers.

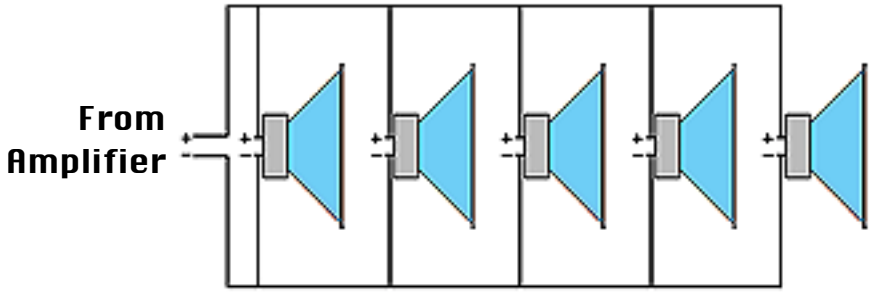


Figure 1.
Speakers wired in parallel.

SURROUND SPEAKER WIRING

The 10 speakers in theatre "A" were wired in two parallel groups of five each. In other words, each speaker was connected directly to the output terminals of its amplifier. See Figure 1. The speakers in theatre "B" were wired in series-parallel groups. This meant that the some of the speakers were connected in series with other speakers, dramatically increasing the effective resistance of the wiring circuits between the amplifiers and the speakers. See Figure 2.

In the world of audio, it is best to keep the resistance of speaker wiring to a minimum, perhaps no greater than 1/4 ohm from the amplifier to the speaker and back. A surround speaker with a minimum impedance (perhaps most easily understood as the total of the electrical factors that impede the current flow) of 6 ohms will therefore add about 6 ohms of resistance to the speaker wiring if it is in series with another speaker. The more speakers one wires together in series, the worse it gets. If five of these surround speakers

were wired in series, each speaker would see an effective resistance of as much as 24 ohms between itself and the amplifier, or 96 times greater than it should be. In order to reduce this series-parallel resistance problem, groups of speakers are wired in several parallel groups of speakers wired in series. If in the above example, we wired our five speakers in two series groups, one of three speakers and the other with two, the resultant load on the amplifier would be reduced from 6 x 5 ohms, or 30 ohms, to about 7 ohms and the effective wire resistance between a speaker and an amplifier would be reduced from 24 ohms to about 6 ohms in the group of two speakers and about 12 ohms in the group of three.

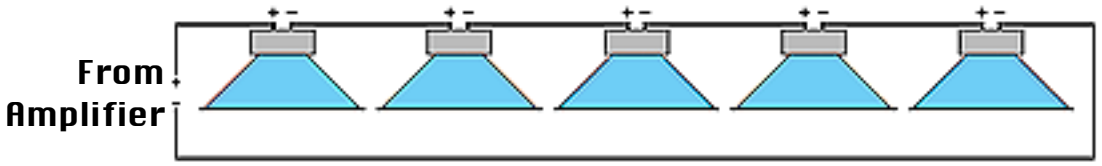


Figure 2.
Speakers wired in series.

When one wires five surround speakers with a minimum impedance of 6 ohms entirely in parallel, the amplifier will see a very low impedance load, perhaps as low as 1.2 ohms. This is typically far below what an amplifier can live with. Most amplifiers can easily accommodate load as low as 4 ohms. The best amplifiers can drive 2 ohm loads. An amplifier with a 2 ohm minimum load capability makes the job easier for the sound system designer as more speakers can be wired in parallel with each other before the amplifier is compromised.

In the case of theatre "A," the surround speakers were specifically designed to have a minimum impedance of about 10 ohms. As such, five of these speakers can be wired in parallel, presenting a load on the amplifier of an entirely acceptable 2 ohms. Loading the

amplifier at its minimum 2 ohm capability also means that the amplifier will deliver its maximum power, nearly twice the power it would deliver into an 8 ohm load and still more depending on the amplifier's power supply.

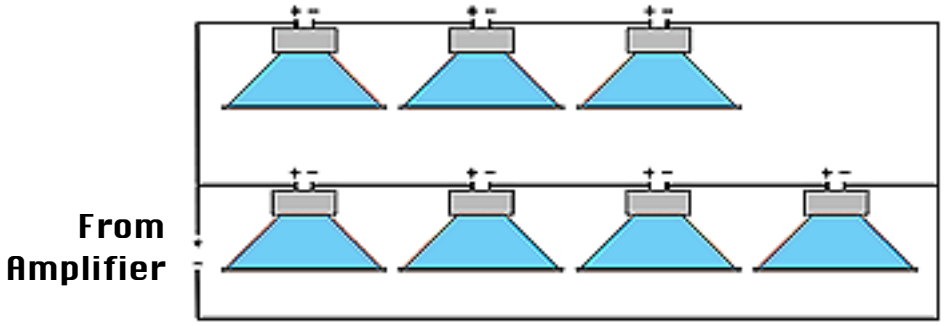


Figure 3.
Speakers wired in series-parallel.

Theatre "B" had seven surround speakers per surround channel. A group of four speakers wired in series was paralleled with another group of three speakers. See Figure 3. These speakers have a nominal impedance of 8 ohms. One can assume that the minimum impedance, though not specified, is somewhere around 4 to 6 ohms. This would have presented a load for the amplifiers of about 6.9 to 10.3 ohms. If this load could have been reduced to 2 ohms, the available amplifier power would have increased significantly.

Another problem with surround systems wired in series-parallel groups is uneven power distribution among the speakers. This is due to the uneven impedance that results between the two groups of speakers when they contain a different number of speakers. Because of the series-parallel wiring in theatre "B," some surround speakers were louder than others. This is usually avoided by adding or subtracting enough speakers to ensure an equal number per series group. But adding unnecessary speakers is wasteful and eliminating them reduces the surround coverage in the theatre. The all parallel wiring in theatre "A," however, guaranteed that all the surround speakers would play at the same level.

So how could all the surround speakers in theatre "B" be wired in parallel? Well, they couldn't unless something else was added -- an impedance matching autotransformer, and a rather hefty one at that. Wired in parallel, a group of seven of the surround speakers in theatre "B" would have presented the amplifier with a load of .57 to .86 ohms. Let's assume the lower number of .57 ohms to be safe. By inserting an impedance matching transformer wired to multiply this by 4, we present the amplifier with load of 2.28 ohms. See Figure 4. The benefits are two to four times more amplifier power as well as cleaner sound with more punch from the speakers themselves thanks to the lower effective resistance in the speaker wiring.

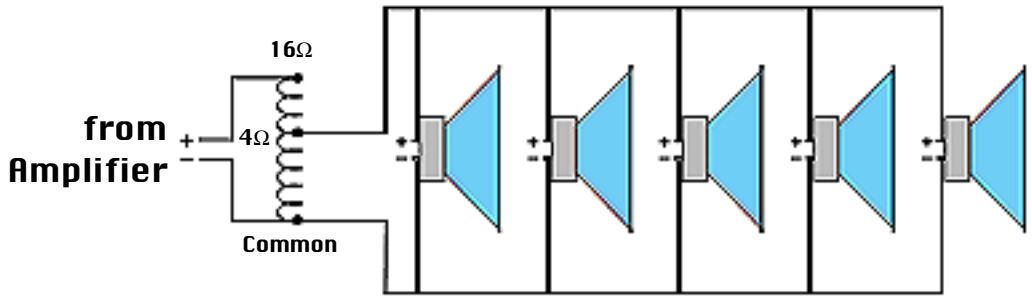


Figure 4.
Parallel wiring with
impedance matching autotransformer
shown with a four times impedance match.

Another well known approach for wiring surround speakers employs 70 volt transformers. This tried and true system will also work well. It's only disadvantage is cost as a transformer is required for each speaker.

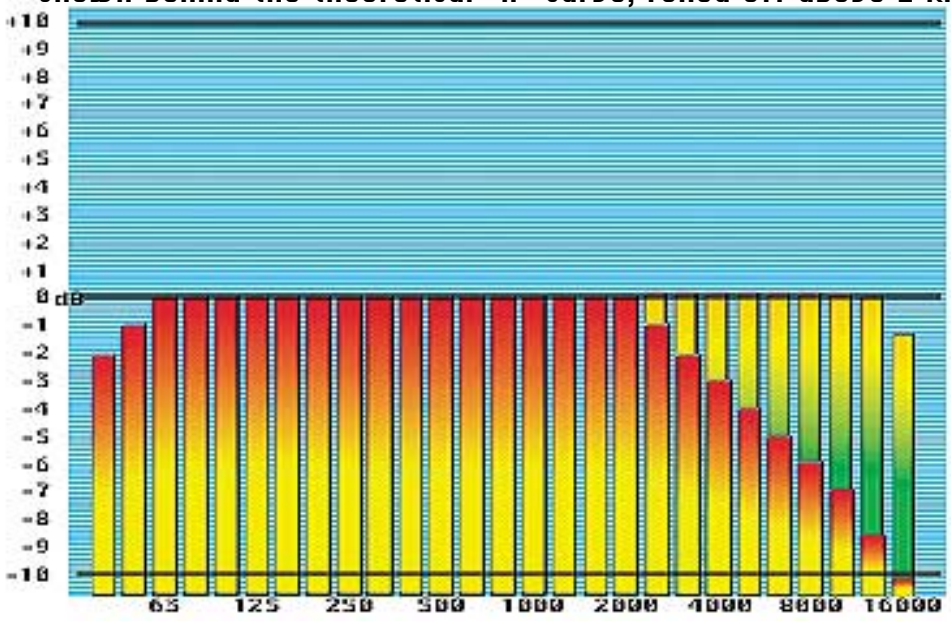
SURROUND SPEAKER PLACEMENT

One of the least understood subjects in the design of motion picture sound systems is how to efficiently locate surround speakers to create the uniform sound field with an absence of directional cues. It used to be common knowledge that there were "no sure fire formulas" or methods for locating surround speakers. In 1980, as I was designing my first full scale Dolby stereo installation, I discovered that it was possible to place the speakers according to a series of mathematical formulas. The resulting coverage uniformity was

within ± 1/2 dB and without any distracting directional cues. No one could tell where a single surround speaker was, even if seated underneath one. Since then, several accounts of other formulas have been published or promoted.

In one case a set of formulas was published in this magazine. However, careful analysis of these equations showed them to be useless. Whether intended or not, the formulas contained a constant that made it impossible for their use to result in speaker spacing that matched the claims of the author. Removing the constant helped the spacing, but left us with the fact that the surround speakers would be installed at the same height no matter the size or shape of the seating area. That won't work either. Unfortunately, the systems I have heard that were designed with other highly touted methods, failed to produce a good surround field. The surround effects could best be described as "here a sound, there a sound." Clearly the exhibition industry needs better than this.

Desirable surround frequency response, measuring flat to 12.5 kHz, shown behind the theoretical "X" curve, rolled off above 2 kHz.



Frequencies on octave centers

Figure 5

SURROUND SPEAKER EQUALIZATION

As I have written several times, the methods used for measuring and equalizing motion picture sound systems are extremely flawed. Nowhere is this more evident than in the equalization of the surround channels. For one thing, since the measurement microphones

are so close to so many speakers, they are always effectively in the near-field of the surrounds. Therefore the ratio of direct sound to reverberation is very high -- much greater than for a screen speaker. It is the rather large amount of reverberation that is present in the measurements of screen speakers that causes these measurements to exhibit a rolled off high frequency response that is far greater than reality. Yet technicians regularly and mistakenly equalize the surround channels to resemble the response of a screen channel. This effectively shuts off the higher frequencies from the surrounds and is one of the main reasons the audiences ultimately hear so little from them.

Many surround speakers are sold with a switch that rolls off the high frequencies in order that the surround array will "conform to the industry standard" frequency response characteristic specified for the screen speakers. This has always struck me as rather odd since the standard neither addresses or pertains surround speakers. Therefore, I would offer two recommendations: First, if found, place all frequency response switches on surround speakers in their flat position. Second, when equalizing surround speakers, adjust them for a frequency response that is flat to 10,000 to 12,000 Hz. See Figure 5. Even if the quality of the speakers themselves isn't what it should be, at least the audiences will get to hear them.

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John F. Allen is the founder and president of High Performance Stereo in Newton, Mass. He is also the inventor of the HPS-4000® cinema sound system and in 1984 was the first to bring digital sound to the cinema. John Allen can be reached by E-mail at johnfallen@hps4000.com.