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# DIPOLAR CONFUSION

The case for dipole surround speakers • Tomlinson Holman

# DIPOLAR NOISE

MANY PEOPLE planning to upgrade their stereo systems from two channels to five or more channels are confused about whether they should use direct-radiating or diffuse radiating surround speakers. A preference for diffuse-radiating surrounds — usually dipoles — is well established for playback of movie soundtracks, but are dipoles also best for multichannel reproduction of music? That is not an idle question considering that DVD-Audio standard is close to being defined, and by next year we may start seeing 5.1-channel music DVD's (some discs might include still pictures, but most of the space will be for audio).

Corey Greenberg's "High End" column in the February issue (titled "Dipolar Disorder") expressed his preference for direct-radiating surround speakers for music. Unfortunately, he also muddied the waters a bit, particularly by repeating the story (often heard from audio dealers) that dipole surrounds were developed as a bandage for a problem with matrixed Dolby Pro Logic surround sound. Since Pro Logic has only one surround channel, but feeds two speakers from it, it makes sense to suppose that the dipole surround speaker was invented to overcome the effects of a single DPL surround channel presented over two side-mounted speakers. The most important effect is localization of the surround-channel sound either in the listener's head, if he is seated exactly on the center line between two identical surround speakers, or else at the closer speaker if he is seated off center.

It's a plausible story, but dipole surround speakers were *not* invented to overcome this problem of Dolby Pro Logic. The use of dipole speakers for *increased diffusion* of ambience goes back at least to 1974, long before Dolby Stereo theater sound was transferred into consumer media. In those days, it was in vogue to "recover" ambience from stereo recordings by extracting a difference signal

(L - R, or left channel minus the right channel) and then sending it through a time-delay circuit to make sure transients stayed localized in the front image by means of the "precedence effect" (this is also the reason for the surround-channel delay in Dolby Pro Logic systems). I did just that in a kind of prototype home-theater system I built using an Advent VideoBeam 1000A projection TV, a pair of Klipsch La Scala speakers (which have controlled vertical directivity) in front, and a pair of KLH Model 9 full-range panel-dipole electrostatics located to the sides of the listening area, with their dipole "nulls" (direction of minimum sound radiation) pointed toward the listeners.

There were no Dolby Surround-encoded recordings in those days, and not even any consumer VCR's, so what to do for program material? Stereo TV (MTS) had yet to be invented, so the only programs available at home with both a picture and stereo sound were "simulcasts" (broadcast on TV and FM simultaneously) of *Don Kirshner's Rock Concert*.

On more than one Saturday night I brought in naïve listeners — Harvard students — and demonstrated this setup to them. The students did not know that the panels at their sides were loudspeakers, and I did my best, by riding gain between front and back, to keep them from realizing what was going on. Everyone who heard this system was very impressed by its ability to produce a sonic image in front and *diffuse* ambient sound all around at one and the same time, but they weren't at all aware of how it was being done. So the dipolar approach was not invented to cure the surround-localization problem of Dolby Pro Logic, which hadn't been invented yet anyway. (The localization problem has since been solved by THX "decorrelation" processing.)

## Why Dipoles?

Another myth commonly heard in stores that should also be questioned

is that discrete 5.1-channel sound does away with the need for dipoles. Advertisers and dealers oversimplify for marketing reasons, speaking as though THX were an "answer" to Pro Logic and Dolby Digital (AC-3) an "answer" to THX. The truth is that THX circuitry does post-processing on audio signals delivered by Pro Logic, Dolby Digital, or DTS decoders in order to get closer to the intent of the originators of the program material. In the case of a movie soundtrack, THX processing is designed to enable a home theater "to accurately recreate the film mixing stage where the soundtrack was created, allowing you to hear the soundtrack that the filmmaker intended," to quote from the Dolby Labs Web site.

One reason I was looking into such a system in the mid-1970s was that even though quadraphonic sound had failed, it still seemed desirable to seek a more spacious effect than we could get by looking through the sonic window generated by just left and right front speakers. Quad failed not only because of the war between incompatible delivery systems — matrix vs. discrete, QS vs. SQ vs. CD-4 — but also because it didn't work as promised even with four discrete channels on a high-quality master tape. The engineering effort had all gone into delivery media, with virtually none into recording and reproduction techniques. When the BBC studied quad in detail, with the four speakers arranged in the traditional square, it was found to be sorely lacking in the ability to image sound from various directions: imaging worked fairly well in front and back, but it was very poor at the sides. Thus, the idea that all the speakers in a surround-sound setup should be identical is questionable, because not even identical speakers result in equal sound all around the listener.

Despite quad's failure, it is nonetheless useful to be able to "break the proscenium" with

# DIPOLAR CONSUMOS

surround sound, extending imaging beyond the front of the soundstage. A psychoacoustic experiment was done in 1972 to determine the minimum number of channels necessary to make a sound field audibly diffuse. (The reverberation component of recorded sound should be reproduced as a diffuse sound field, since that is what occurs with reverberation naturally.) Twenty loudspeakers were set up in a circle, each 18 degrees apart, and various numbers of them at varying angles were activated with separate noise sources. The key finding was that it took a minimum of five channels to produce a diffuse sound field.

Before we celebrate that our current 5.1-channel systems have it covered, however, let's look at the angles required to produce the effect of sonic envelopment (see Figure 1):  $\pm 36$  degrees off the center axis, which is close to what we're used to with stereo speakers;  $\pm 108$  degrees off-axis, which corresponds well with the usual recommended placement for left and right surrounds; and 180 degrees off-axis, or directly *behind* the listener! For the best frontal imaging, though, we've learned that a center front channel is required, and something that all multichannel delivery systems provide (Figure 2). How can we reconcile these seemingly contradictory requirements?

Fast forward to 1986, the year that the dollar value of video recordings sold exceeded that of movie tickets sold. I began researching how to recreate the experience of the best motion-picture theaters at home. This was a logical follow-up to the theatrical THX system, which was designed to help movie theaters achieve what the directors and mixers of the films intended. Of course, I remembered that earlier experiment, but I wanted the foundations of Home THX to be even more scientific.

Two different listening panels were formed, one made up of people naïve about sound

reproduction (they had only simple stereo systems, if any at all) and one made up of very sophisticated listeners indeed — the very people who had mixed the soundtracks of the films represented in the tests. Both panels did blind A/B comparisons between systems using dipole and monopole (direct-radiating) surround speakers, with the levels and frequency responses of the different pairs of surrounds carefully matched so that radiation pattern was the principal variable.

*All of the listeners in both panels preferred the dipole surrounds over the monopoles, and for exactly the reason that Corey Greenberg cited in his column, that dipoles “deliver a more expansive sense of ambience.”* The direct-radiating surrounds were easily localized by the listeners and thus failed to give a surround effect. I reported these results in the *Journal of the Audio Engineering Society* (the audio industry's equivalent of the *New England Journal of Medicine*).

Corey, however, also said that he finds “more detail” with monopole surrounds, and he therefore prefers them for music as opposed to movie soundtracks. One reason he hears more detail with monopoles is that he hasn't compared the two kinds of speakers in a system where their levels and frequency responses are matched — the dipole surrounds he used to discredit the principle weren't even THX-certified, which would have helped produce a relatively flat response at the listening position. The original intent of the Home THX specifications was to match the response of the dipole surrounds with that of good monopoles so that either could be used interchangeably to reproduce surround-channel signals, without the surround-channel response getting noticeably brighter or duller, for instance, when switching between them.

For a match in frequency response between the two types of surround speaker, the dipole surround has to have flat *power response*, that is, flat response measured as a sum of the speaker's

output in *all* directions, not just in one particular direction. A good conventional monopole (direct-radiating) speaker should also have a flat response, but measured only on and close to its main axis of radiation. If both the monopole and dipole are THX-certified, the response of the two types should match. Corey's listening experience with two unmatched speaker models could have been overwhelmed just by the frequency-response differences between them — a brighter loudspeaker will be perceived as producing “more detail.”

## Surround Utopia

I recently participated in the design of a home-theater-style listening environment for a major Hollywood studio, built so that the sound engineers can assess video releases under highly standardized yet homelike conditions. We started with a blank slate and were able to specify everything about the room, including the dimensions and acoustics, as well as all parts of the sound system. When it came to surround speakers, I asked for *both* types (dipole and monopole) to be installed, with an A/B switch, and they were adjusted and equalized until their levels and frequency responses matched.

In addition to having used this room for a few hours myself, I also solicited feedback from the longterm users. Most of them agreed with me that envelopment is better with the dipoles (see Figure 3): the front and surround channels seem to integrate better with spatial effects, like thunder rumbling around the room, and front-to-back pans are smoother. When listening closely for quality control, the sound engineers prefer the direct-radiating (monopole) surrounds, because they emphasize defects such as small clicks or dropouts, which are indeed easily localized. But when listening for pleasure, most do prefer the dipolar approach.

One clear advantage in favor of the dipoles is the larger “sweet spot” they make available. The

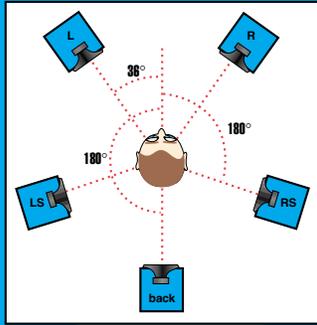


Figure 1. In an interesting psychoacoustic experiment performed in 1972, it was found that to create a diffuse and enveloping sound field, a minimum of five speakers are needed — but one of them has to be placed directly behind the listener. These results help explain why quadraphonic sound failed.

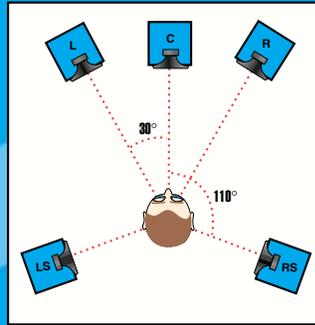


Figure 2. A standard 5.1-channel speaker setup has the left and right front speakers about 30 degrees off the axis where the center speaker is placed, with two surround speakers about 110 degrees off center. But if direct-radiating (monopole) surrounds are used, those five speakers cannot produce the sensation of being immersed in a diffuse sound field as in Figure 1.

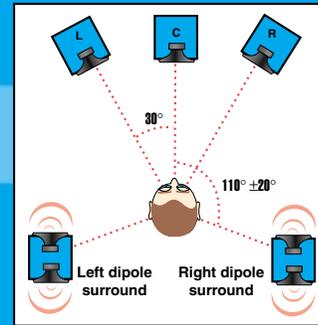


Figure 3. To combine the effect of a realistic sonic image in front of the listener with the effect of immersion in a diffuse sound field using only five speakers, you need diffuse-radiating (dipole) surround speakers. Dipole surrounds also produce a larger “sweet spot” for listening compared with monopoles.

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level of a direct-radiating speaker falls as you move away from it. With a dipole, the null direction is pointed at the listener, so the variation in perceived volume along the null direction is more uniform than with direct radiator, since virtually all the energy received along this line has been reflected by the room. This effect widens the listening area for high-quality reproduction compared with the direct-radiator approach.

If you think that home theater, with its emphasis on frontal images and surround envelopment, is the only reason for the dipolar approach, think again. Diffuse ambience is just as important for pure music reproduction. Probably the most popular multichannel work to date has been John Eargle’s recording of Tchaikovsky’s *1812 Overture* with the Dallas Symphony. John says that the best reproduction of it

he has heard was in a large room at an Audio Engineering Society meeting in Toronto, where the front channels were handled by direct radiators and four dipole surrounds were used to reproduce the ambience of the space where the recording was made, the well-respected Meyerson Hall in Dallas. He says that he could “walk the room” in Toronto and get an experience like “walking the hall” in Dallas.

Both surround approaches have adherents, as Corey Greenberg’s column suggests. If you’re not convinced one way or the other, you could have it both ways with M&K’s “Tripole” surround speakers or similar approaches from other manufacturers.

Ultimately your choice, if unaffected by marketplace “noise,” will most likely tend toward dipoles if you listen for pleasure

with family and friends to movies or to music placed in an acoustic space, and toward monopoles if you want to be alone, in the middle of the band. Probably the marketplace has made too much distinction between these types of surround speakers since each type produces both a direct and diffuse sound field. How much sound image or sonic envelopment is emphasized relative to the other is really just a matter of degree.

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