Omnidirectional Radiation

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Science and technology as well as the arts have been characterized by controversy, and audio is no exception with such arguments as "pentodes vs. triodes" in amplifiers, the relative importance of measurements vs. listening tests in evaluating loudspeakers being typical. Sometimes the controversy is more imagined than real and derives its substance from insufficient knowledge, or over-simplification. It is the purpose of this article to discuss a recent "controversy" over the relative merits of omni-directional and "conventional" speakers.

Ideally, the performance specification sheet for a loudspeaker should look the same as one for an amplifier, with the exception of a few physical descriptors of one that do not have an easily definable counterpart in the other (e.g. output impedance). A loudspeaker, however, propagates sound in a three-dimensional continuum, whereas the signals processed by the amplifier are propagated in one, a pair of wires. Because of this, an additional important set of data is needed to show how the acoustic power is radiated in the various directions. It is a statement which is not generally discussed in any great detail because representation of the data is cumbersome (imagine looking at sixteen frequency response curves depicting the performance as it varies with direction from the source). But, we would like to discuss this difference between the loudspeaker and other elements in the audio reproduction chain because it is basic.

It is possible to argue, because of the variety of available room placements, that a loudspeaker should radiate uniformly over a solid angle of between π and 4π steradians. Further, the *power* output in free space (not simply axial pressure vs. frequency response) may have a special form to account for the increase in output at low frequencies resulting from wall reflections. It is not acceptable to have a uniform radiation pattern over 4π steradians at low frequencies, becoming directional at middle and high frequencies in such a manner that the net result is a non-uniform pressure vs. frequency characteristic in the reverberant field of the listening room. And yet, this is not uncommon.

Since non-directional behavior or controlled broad directivity is nominally desirable, from where derives the prejudice in some quarters against omnidirectional speakers? First, some speakers considered to be omnidirectional are not, but instead are directed-reflected type radiators. Second, those who feel that omni's are deficient in certain areas may be making generalizations from a very few poor examples. We are not aware, prior to now, of the existence of true omnidirectional speakers as serious contenders in the high performance speaker race. It would seem that omni's are put down in absentia—despite the fact that designers of conventional speakers generally strive to make speakers non-directional over as much of the frequency range as they can manage.

The question more properly may be, are there any true omni speakers? The answer is no. It is exceedingly difficult to produce a speaker that has uniform radiation over a spherical surface in the near field. What happens in the reverberant field (where people normally listen) is another matter. It is possible to produce a speaker which is essentially a true omnidirectional source, as heard in the reverberant field. It does not suffice, however, to place a number of driver units of individually indifferent frequency responses on the surface of a sphere and hope to get good results. True, omni behavior will result but at some cost in frequency response. Suppose we assume a good design—are there problems uniquely associated with omni's, and are they inherent? I do not think so, but a discussion of potential difficulties is worthwhile.

A true omnidirectional source must be either a point source (not possible) or a finite pulsating sphere (not practicable). In practice, an omnidirectional speaker comprises sources so small as to be non-directional as a consequence of their smallness, or sources of known directivity occupying a fraction of a "spherical" surface and equalized so that they radiate constant power vs. frequency, or some combination of the two. If there is any faulting of this approach it may be in the requirement for a multiplicity of sources. What happens is this:

In the frequency range where a number of sources are radiating, the pressure vs. frequency response characteristic will be a function of the microphone position and, in general, will not be "flat". But this is not what we hear. We hear the integrated power output as modified by the listening room characteristics. This poses no problem, if the integrated power output is constant with frequency. There is a possible unlooked-for effect, however, with regard to stereophonic localization. If two multiple driver speakers are so placed with respect to the listener that he does not receive the same "free field" response from both, the stereo images will be imprecise. This may appear to be a significant flaw until one thinks more about the whole process of localization.

Obviously, the problem is potentially most severe if the entire range is covered by a number of drivers, since then the non-uniform response with direction will extend to relatively low frequencies and have more of an effect on the stereo information received by the listener, *if* the speakers are not symmetrically positioned. (If only part of the spectrum is covered by multiple units, it is only the stereo information in this range that may be affected). But, this can be prevented by symmetrical speaker placement. Indeed, symmetry of the listener himself with respect to the two sources is essential to preserve the accuracy of the stereo images, since the process of stereo localization depends on the perception of time and intensity differences between the two channels. These intensity differences are in large measure vitiated by the movement off the axis of symmetry by the listener of approximately one foot. This is because a time of arrival difference of approximately 1 msec. makes necessary an increase of almost 10 db for the later source to be perceived as existing—lacking in this, the sound will appear to come entirely from the near source. Such constraint on the listener is more restrictive than the requirement of symmetrical orientation of speakers. In fact, with omni-directional speakers the tendency to lose the stereo effect is less when the listener moves away from the axis of symmetry—a significant advantage.

Finally, the acoustic characteristics of the listening room are far more important than most people realize. Because the ratio of reverberant to direct sound from omnidirectional speakers is higher than that from more directional types, the effect of the room is correspondingly greater. Since many listening environments (e.g. some audio dealers' showrooms) are less than good acoustically, an omni speaker may come off second best in an A-B listening test with a more directional type. However, for one who does not wish to be fixed in space for his listening enjoyment, and can provide a reasonably good acoustic environment, an omni-directional speaker system is definitely advantageous. AE