Distributed-mode loudspeakers and their impact on intelligibility in multimedia and sound distribution.

Peter Mapp* and Henry Azima**

*Consultant, Colchester UK CO3 4JZ and **New Transducers Ltd Huntingdon UK PE18 6ED

Abstract: A new class of acoustic radiator has been investigated and shown to exhibit unusual radiation characteristics that can produce enhanced intelligibility under given listening conditions. The improvement mechanisms are investigated and shown to be related to a number of unique features. These include transient response, synergetic decay, lower inherent distortion and diffusivity of the acoustic radiation.

INTRODUCTION

In sound system design, it is desirable to produce an even sound coverage, both in the spatial and spectral domains. Conventional radiators, the majority of which work under a pistonic regime, exhibit three important characteristics that limit their potential effectiveness in real world applications. These are the well known narrowing of acoustic radiation (dispersion) angle with increasing frequency, the non-uniform sound power output and the coherency of the radiation. The narrowing radiation and non-uniform sound power output, result in a non-flat frequency response for the reflected / reverberant sound field. However in many systems, the reflected sound field component in fact dominates the situation, resulting in a poor overall sound balance and possible loss of intelligibility. (1, 2).

In contrast, Distributed Mode radiators, an emerging new technology, tend to overcome these obstacles and offer a new approach to improved sound distribution and multimedia. They combine a flat power response with an essentially constant and wide directivity, augmented by a spatially and temporally diffuse radiation characteristic. The fast transient response results in a signal broadcast with very high clarity, whilst the diffuse nature of the radiation suggests a lower degree of boundary interaction and spectral interference.

By encouraging reflections to occur within the first 35 to 50 milliseconds [i.e. a period relating to the information integration time of the ear (3, 4)], intelligibility may be enhanced and the subjective loudness increased. Although conventional (pistonic) loudspeakers can also create such sound fields, they suffer from the limitations noted above. For this reason, in conventional sound system design, it is normal to try to minimise excitation of the reflected sound field and so overcome such limitations. Correctly designed Distributed Mode Loudspeakers however, enable full use of this technique to be adopted to advantage. (5, 6)

Conventional loudspeakers can also suffer from specular reflection / boundary interference effects. These can lead to significant spectral distortion, coloration and comb-filtering. The positioning of such loudspeakers, either in a room or in relation to a boundary is therefore critical if such undesirable effects are to be avoided or at least minimised. It is demonstrated however that Distributed Mode Loudspeakers suffer far less from these effects and that their unique radiation properties can result in improved coverage and perceived clarity.

BENDING WAVE / DISTRIBUTED MODE LOUDSPEAKER TECHNOLOGY

Bending wave behaviour in plates and panels has been extensively documented and is well understood. However, this theoretical work has generally concentrated on the control of such bending to minimise the transmission and radiation of sound energy. The solutions to the bending wave equations are complex and depend critically on the edge boundary conditions. Historically a number of attempts have been made to construct effective loudspeakers using quasi-rigid panels operating either partly or largely in bending. Producing bending wave operation over part of the audio frequency range is reasonably trivial. Indeed many diaphragms that suffer departure from their intended pistonic operation, unintentionally enter bending motion and so radiate sound by virtue of bending wave action. However, to deliberately create bending wave radiation over a wide audio frequency range in tandem with high quality sound reproduction is a complex task and is the subject of many patent applications. With care, this can be achieved over an 8 octave range. (7).
DISTRIBUTED MODE LOUDSPEAKERS IN MULTIMEDIA APPLICATIONS

The electroacoustic aspects of multi-media are extremely diverse, ranging from Home Cinema to Personal Computers and from Laptop computers to personal communication systems and sound reinforcement. The potential advantages of being able to create flat and very thin / low profile loudspeakers are immediately obvious, enabling loudspeakers to be seamlessly integrated into products or environments hitherto impossible. For example by coating or laminating a distributed mode loudspeaker with an optically reflecting surface, a combined loudspeaker / projection screen can be created. By projecting a video or optical film image onto such a screen, a natural synchronisation between the visual and acoustic signals may be produced. The application for centre channel home cinema systems or boardroom / conference room audio-visual systems is an obvious one. The wide dispersion and time-energy characteristics of the Distributed Mode loudspeaker technology can also be used to take full advantage of the reduction in boundary interaction effects, the improved coverage, greater early sound density and greater intelligibility and clarity. These attributes, together with the diffuse sound field created also makes the distributed mode loudspeaker an interesting basis for surround sound loudspeaker systems for Home Cinema and allied fields. A very wide stereo image has been noted to be produced without the limitations of the conventional stereo ‘sweet spot’ enabling a larger audience to be catered for. Rear channel and surround loudspeakers have also been found to be less localised, again enabling a larger effective listening area to be created.

In computer based applications, Distributed Mode loudspeakers can be made thin enough and small enough to even be installed in Laptop computers, resulting in improved sound quality / bandwidth and perceived loudness over traditional miniature types.

In sound reinforcement, the flat power response, wide dispersion and unique radiation characteristics may also be used to advantage. Again such systems can benefit from the improved sound density and an interesting by-product of the acoustic radiation characteristic has been noted - that of improved gain before feedback margin.

CONCLUSIONS

Distributed Mode Loudspeakers have been found to offer a number of advantages over conventional pistonic devices for a wide range of applications and multimedia in particular. Their nominally flat power response, wide dispersion and synergetic decay coupled with the diffuse nature of the sound field not only can bring about perceived subjective benefits but also suggest that many traditional design and evaluation techniques may need revising if the full potential of this unique loudspeaker form are to be fully realised.

REFERENCES

2 Mapp P, Doany P, Speech intelligibility analysis and measurement for a distributed sound system in a reverberant environment. Presented at AES 87th convention New York 1989
3 Corliss E, The ear as a mechanism for communication. JAES, vol. 38, No 9 1990
4 Lochner JPA, Burger JP, The influence of reflections on auditorium acoustics. JSV vol. 1 1964
5 Mapp P, Gontcharov V, Evaluation of Distributed Mode loudspeakers in sound reinforcement and public address systems Paper to be presented at AES 104 Convention Amsterdam 1998
6 Mapp P, Colloms M, Improvements in intelligibility through the use of distributed mode acoustic radiators in sound distribution. AES 103rd Convention New York 1997
7 Harris N, Hawksford M O, The distributed Mode Loudspeaker as a broadband radiator. AES 103rd Convention New York 1997

2410