B. Excess Phase Equalization

The phase response of a loudspeaker through its low frequency roll-off can be equalized using digital delays producing subjectively a deeper and tighter bass response.

C. Magnitude Response Equalization

Digital signal processing can also be used to equalize a drive units magnitude response. However, in most cases, response anomalies will be polar dependent and therefore not equalizable with a single dimension equalizer. Magnitude equalization should therefore be applied with great caution.

3. Time Domain Anomalies

A high performance loudspeaker should have no high Q or delayed resonance's and must also minimize multiple arrivals of the same signal caused by reflections and diffraction effects as these add a hard and claustrophobic coloration to the sound, masking ambient detail and confusing the stereo image. Time domain anomalies are without doubt the most intrusive and tiring to the listener of all distortions. Careful drive unit and crossover design can ensure a flat and even magnitude response free from any low Q broad band resonances or response irregularities. High Q and delayed resonances however, which are common in hard undamped diaphragms and poorly designed crossover filters, are not so easily ameliorated. In fact the only successful solution is to design heavily damped flexible diaphragm structures having high internal resistance and great structural integrity even under high drive levels.

Best results have been achieved using quite steep curvilinear and domed diaphragms formed from polycotton and acrylic fabrics which are impregnated with plasticized PVA and other viscous damping mediums to control resonant break-up modes which occur at high frequencies.

It is also equally important for the fundamental system resonance to be well damped, that is, have a Q between 0.3 and 0.6.

Loudspeakers with an under damped system resonance produce ill defined bass which sounds uncontrolled and excessive and masks midrange detail.

In fact what is really being said here is that for a high performance loudspeaker all resonant systems should be at least critically damped whether they are due to diaphragm break-up or the fundamental system resonance.

4. Dispersion and Directivity

The relationship between direct and reverberant sound is very important in high performance loudspeakers. It is clear that not only must the on-axis magnitude response be accurate and linear but also that the behavior off-axis must be both broad and even with frequency exhibiting no abrupt dips in amplitude. The aim should be to achieve a horizontal dispersion of +/-80 deg. With a -6dB @ 10KHz and a vertical dispersion of at least +/-10 deg. To ensure that in a well behaved room with a good RT vs frequency characteristic, The reverberant sound will be consistent with the direct sound in the listening area.

To achieve this criteria the highest performance loudspeakers will be either small two way systems with bass/mid drive units up to 160mm diameter or preferably three way designs where the midrange is no more than 75mm diameter and crosses over from the bass drive unit at around 300 Hz. The tweeter in this system should not be greater in diameter than 34mm and should be crossed over from the midrange at around 3 KHz.

In a well behaved room when listening to a stereo pair of loudspeakers with a good relationship between direct and reverbant responses you will first hear the direct sound and then the reverberant field. It is generally agreed and probably true that the reverberant field masks periodic signals, however, it is also apparent that the ear has a precedence effect which means that for impulsive sounds the ear can hear phase dependent effects. Therefore, we believe that any critical judgment of reproduced sound is made principally on the first arrival or direct sound which gives most of the phase related cues and also the low level detail which is quickly lost in the reverberant field.

However, the way we perceive magnitude band balance and the full energy of percussive or impulsive sounds, is dependent upon the power response of the loudspeaker or how evenly it excites the reverberant field with frequency.

Clearly it is impossible to exclude from such a relationship the effect of room acoustics, however, for the purpose of discussing loudspeaker performance we will assume that the listening room has been properly treated and has no serious intrusive acoustic problems.

It should also be stated here that the use of DSP to equalize loudspeaker room interface problems is not an acceptable solution to that problem in critical listening environments if it involves modifying the direct sound from the loudspeaker. A dramatic effect of poor midrange dispersion, common in many two way loudspeaker systems, is demonstrated by recording engineers making incorrect magnitude band judgments and applying equalization, usually to the upper midrange, in an attempt to compensate for the apparent lack of energy in that region. Many examples of pop recordings are available which demonstrate this characteristic. That is, a hard strident upper midrange which masks high frequencies, and makes vocals sound recessed while accentuating the bass.

Non Linear Distortion

5. Harmonic Distortion

Non linear distortion is the product of non-linearity in a system's transfer function. There are three principal sources of non-linear distortion in loudspeakers and they are all related to the drive system.

The first relates to the voice coil and magnet gap geometry and the non-uniformity of the distribution of magnetic lines along the length of the magnet gap. A short coil in a long gap renders the best solution regarding geometry, although not the most commonly used, and the distribution of magnetic lines will be improved by the use of an undercut centre pole. Further advantages of this geometry are the improved heat dissipation and therefore reduced operating temperature of the voice coil as well as a reduction in the variation of voice coil induction in relation to its instantaneous position in the magnet gap.

The second principal source of non-linear distortion is generated in the suspension system of the diaphragm assembly and is mainly contributed to by the spider. The spider presents a number of difficult design compromises when longer excursions are required in high power drive units. It must exhibit high axial compliance while also being progressively resistive towards the extension extremes so as to avoid mechanical damage and at the same time be very stable normal to the axis so as to ensure good voice coil centering in small magnet gap clearances. ▶