

## The design and development of high performance loudspeakers

The third source of distortion is due principally to the inherently non-linear magnetic performance of steel. The alternating magnetic field created by the voice coil induces eddy currents into both the pole and front plate, adjacent to the coil, of the permanent magnet assembly. These eddy currents flow in such a way as to oppose the magnetic field producing them, (i.e. from the voice coil), and cancel out much of the self inductance.

This mechanism is minimized in ATC bass and bass/mid drive units by the use of a new material, which has the unique properties of high magnetic permeability and saturation as well as low electrical conductivity. We call it a super linear magnet material (SLMM). With this material fitted to the pole and front plate adjacent to the voice coil the eddy currents are suppressed and the impedance (self inductance) increases. The result is that third harmonic distortion is reduced by between 12–15dB.

It is evident from experiment, that distortion caused by eddy currents in the magnet assembly, is worse in long gap than short gap magnets.

In practice it will be careful drive unit magnet system and suspension design that will most effectively minimize non-linear distortion.

Having said all of that, since the main use of loudspeakers is to listen to music and speech, both of which have complex structures dominated by harmonically related tones, the presence of low order harmonic distortion is generally considered to be less audible and more tolerable than other forms of distortion.

### 6. Amplitude Intermodulation Distortion

Amplitude intermodulation distortion, however, is much more intrusive than harmonic distortion due to the products not being harmonically related to the original sound.

A recent review of active and passive loudspeakers at ATC confirmed that active loudspeakers, due to each drive unit amplifier operating only over a restricted frequency band, will have much lower amplifier borne amplitude intermodulation distortion than the same loudspeaker operated passively driven over the full audio frequency range, in fact, a full 20dB difference.

### 7. Hysteresis Distortion

The presence of hysteresis distortion implies that the system transfer characteristic is not always singlevalued for a given instantaneous input and will vary with both the change of direction and the level of the input and that it will therefore produce distortion that has a different phase to that produced by harmonic distortion.

Hysteresis distortion, as much as it exists in loudspeaker suspension systems and heavily damped soft diaphragm assemblies, does not manifest itself as an intrusive distortion. It is certainly not particularly evident in other measurements, for example, transient response, magnitude response or in harmonic distortion measurements. In fact, if care is taken over the choice of both diaphragm and suspension materials then they will largely have the characteristics of a simple damped spring and exhibit negligible hysteresis.

### 8. Dynamic Range

The issue of dynamic range is a complex one and although it is primarily controlled by voice coil operating temperature and magnet total flux it must be considered along with the mechanical integrity and freedom from break-up of the diaphragm and suspension structure. There can be no doubt that system dynamic range significantly effects the clarity of reproduced sound. Even quite simple combinations of instruments, for example a string quartet, will produce a maximum SPL well in excess of 100dB at 2m when starting from just audible pianissimo passages.

A loudspeaker that has significant power compression will tend to sound dull and boomy and the high voice coil temperature and consequent resistance rise will effect the loading of the passive crossover and therefore also modify the magnitude response of the system.

The dynamic range of direct radiating loudspeakers is in fact almost entirely determined by cost. Designers do strive to produce more sensitive small systems through the use of very light diaphragm structures but the scope for maneuver is limited if a correct balance between bass and midrange magnitude response is to be achieved for a given diameter of drive unit. Furthermore, light diaphragm structures almost always have low internal damping and therefore a tendency to exhibit high Q resonances.

To qualify in all respects as a high performance loudspeaker the requirements of dynamic range will for most designs be the largest compromise. A choice, which is made much more difficult as a consequence of the rapid developments in digital electronics



ATC SCM150A active monitors, Blackbird Studios, Nashville

during the past decade. Digital recording mediums offer a huge dynamic range with a peak to average of typically 12–16dB which means that even the most modest loudspeaker wearing the tag "high performance" must be capable of continuous output of at least 94dB at 1m while being driven from an amplifier of 100 watts or more.

### 9. Motional Impedance

The complex motional impedance of a typical two or three way passive loudspeaker system must have a modulus of impedance which varies within defined limits, never falling below the voice coil resistance. A minimum impedance modulus which does fall below the voice coil resistance indicates a ringing filter in the passive crossover which will cause time domain distortion as well as presenting a difficult load for the driving amplifier. ■