Technical White Paper

Super Linear Magnet Technology

Since the invention of the moving coil loudspeaker, designers have been looking for ways of improving the sonic performance of their systems. No-one has put more emphasis on this than ATC, and with the development of the Super Linear magnet system, one of the longest standing obstacles to audio engineering perfection has been removed.

The detrimental effects of magnetic hysteresis have been known about for many years, but it has taken a combination of timing, with the right material coming to the market, and ATC's engineering abilities to bring the technology into loudspeakers.

HYSTERESIS

The magnetic performance of steel is inherently non-linear. From work first published back in the '30s (mainly concerning transformers and rotating machines) hysteresis has been known to be at the root of the problem, with the induction of eddy currents a compounding factor.

Although much work has been published in the field of hysteresis distortion in loudspeakers, the world has never before seen a production transducer which obviates the distortion mechanism.

ATC has finally cracked this nut with the help of a new material, which has the unique properties of high magnetic permeability and saturation level and low electrical conductivity.

We call it the Super Linear Magnetic Material (S.L.M.M.).

SUPER LINEAR

All ATC loudspeaker systems are now equipped with Super Linear technology. This is in the form of rings of S.L.M.M. which replace the steel regions concentric with the voice coil (see inset overleaf). The effect of the rings is to reduce the third harmonic distortion by 10-15dB between 100Hz and 3kHz. This makes for distortion comparable with most electronics.

THEORY

Experiments were performed on a blocked voice coil with the magnet left un-energised. It could be thought of as a cored inductor. A current was passed through the coil and second and third harmonic distortion components were measured.

Mathematical analysis, in conjunction with the experiments, has revealed some surprising answers to the question of why replacing the steel regions with S.L.M.M. has such a dramatic effect on the distortion.

Firstly, magnetic field in the regions concentric with the coil is reduced by a factor of around 10%. This is interesting because within a non-conducting material, one would intuitively expect the magnetic field to be much lower, as the current density has to be lower. Not so in this case. The field is maintained by the steel pole and frontplate.

Secondly, the presence of the S.L.M.M. increases the self-inductance of the voice coil. When eddy currents are allowed to circulate in the system, they oppose the magnetic field producing them (i.e. that from the coil) and "cancel out" much of the self-inductance. With the S.L.M.M. in place, eddy currents are suppressed and the self-inductance (i.e. the impedance) goes up.

Thirdly, whilst the impedance, and therefore the fundamental voltage across a blocked coil goes up when the rings are fitted, the harmonic components, that are induced back into the voice coil, stay the same. This is because they are dependent only on magnetic field, which as we have seen, doesn't change very much. The net effect is a rise in the signal/distortion ratio.

THE BOTTOM LINE

Two important issues result from this development in transducer technology.

aural benefits…

Most importantly, we have achieved a significant improvement in sound quality. Reducing the level of distortion by such a dramatic amount has revealed another layer of information to the listener. Ambient sounds and low level effects that were previously masked are now clearly audible and provide an enhanced sense of realism. The articulation of male vocals is markedly improved and piano reproduction is given a new lease of life.

scientific benefits…

The difficulties in solving non-linear field problems have constrained past research efforts to semi-empirical numerical approaches, and no-one has really been able to analytically pin-point the mechanism by which the distortion was entering the voice coil current. The complexity of the mechanism and the diversity of contributing phenomena explain why it has taken the industry so long to solve this particular distortion.

CONCLUSION

The introduction of Super Linear technology has heralded probably the most important development in transducer design for the past fifteen years. It has been a practical success in that transducers incorporating the technology are in use across the whole range of ATC systems, and the improvements in sound quality are not subtle.

Furthermore, ATC have analysed and succeeded in defining the complex non-linear electromagnetic mechanisms within the transducers. This work should pave the way for a new generation of transducer technology.