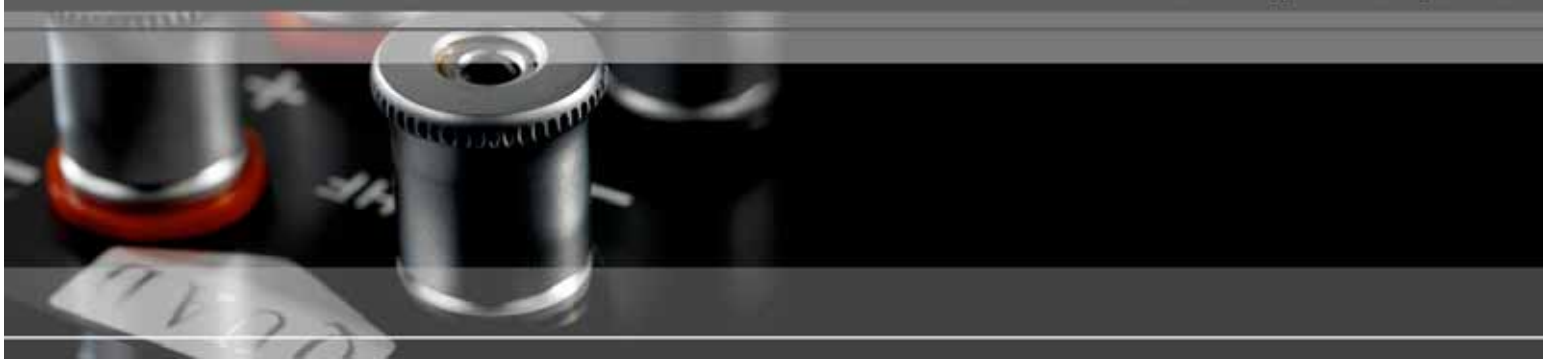


# L2 Series Moving-coil Loudspeakers – Technical Overview

## 1. Introduction

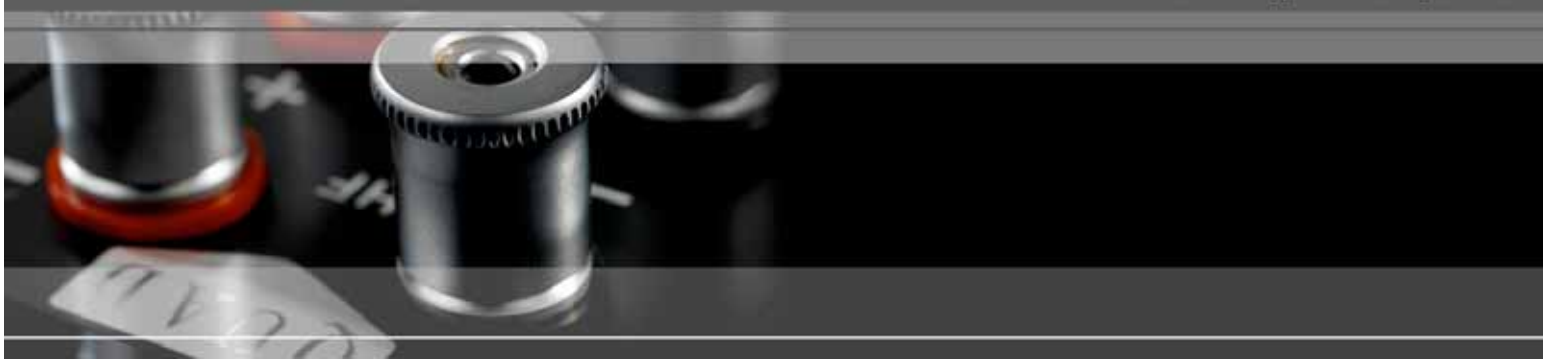
The Quad L2 series is the latest incarnation of the now legendary range of Quad moving-coil loudspeakers. The range has been improved in almost every area to fulfil a number of key design criteria.

a) To improve on all previous performance criteria with wider bandwidth, lower distortion, better mid-range integration through the use of the latest advances in manufacturing and acoustic understanding
b) To retain and enhance the traditional aesthetic, whilst manufacturing a cabinet that has less colouration and a more rigid construction
c) To extend the range with a series of new models designed for a range of new applications.

## 2. History of the Range

The Quad L2 series loudspeaker range is actually the third generation of moving-coil loudspeaker launched by Quad. The first of these, the 10L was launched as part of the 77 Series range of electronics and consisted of a single 2-way model.

In 2002, Quad launched the next generation the L-series, which consisted of a range of models starting with the 11L and moving up to the flagship 2.5way floor-standing 22L loudspeaker. The range was supplemented with a dedicated centre channel loudspeaker and 300W RMS powered subwoofer. The introduction of the L-series sparked a revolution in the hi-fi industry. Never before had such quality been available at such a competitive price. The technology introduced by the L-series remains at the very leading edge of acoustic science. A unique weave of high-grade Kevlar, the introduction of the most rigid bass driver chassis in its class, a superb new high-resolution tweeter, and the lustrous high-gloss piano lacquered finish all set them apart from their competitors.



# Design Challenges - The L2 series

3. Stereo imaging

Design Challenge

For some years now, it has been widely accepted by acousticians that the ideal loudspeaker should be a pulsating sphere, creating compressions and rarefactions within the air with the sound radiating from a point source. When using two such point sources, the coincident waves arrive at our ears and are interpreted as stereo sounds by our brains. The quality of the stereo 'image' or soundstage is defined by how closely the loudspeaker in question conforms to this ideal point-source theory.

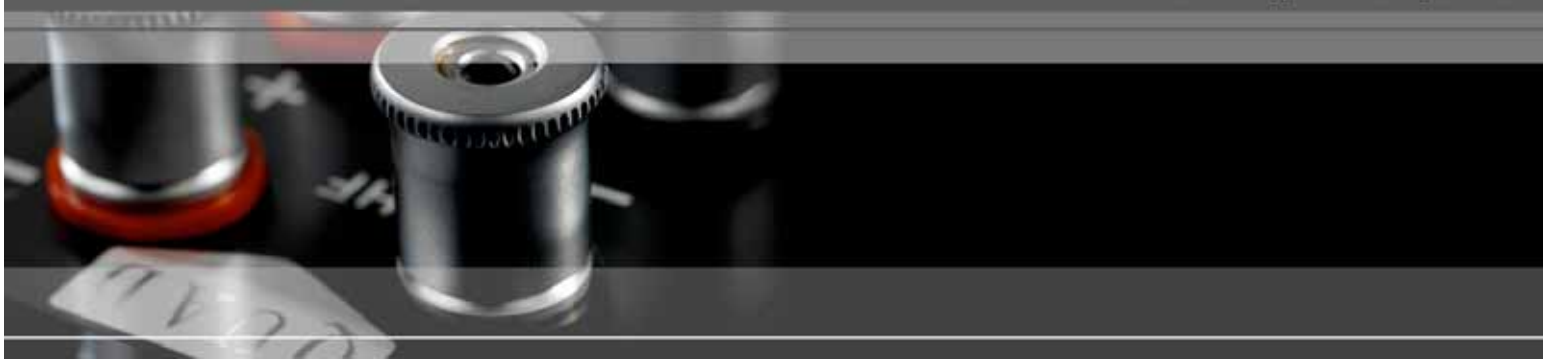
Solution

In addition to the widely adopted method of using a dome tweeter to create a hemispherical radiating pattern, the high-frequency driver and mid/bass drivers are very closely integrated within the design. Complimentary alloy components are used, allowing the main bass driver chassis and tweeter dispersion plate to lock with each other for the closest possible coupling of drive units. This also aids dispersion (see below)

4. **Dispersion Characteristics**

Design Challenge

Whilst bass frequencies are essentially 'directionless' and fill a room very easily, a good dispersion characteristic is very difficult to achieve at higher frequencies, yet for a consistent in-room response it is essential. Problems associated with beaming high-frequencies include a very small 'sweet-spot' or listening position, complex room reflections leading to an inconsistent room response, and frequency response that becomes very susceptible to room furnishings and layouts.



Solution

Our new tweeter, designed in synergy with the whole of the L2 series has quite remarkable dispersion properties. The attached graph (of the bookshelf 12L2 model demonstrates this, showing the forward dispersion characteristic being exceptionally uniform, even at high frequencies and up to 45degrees off-axis. (*See Appendix 1 –Polar response graphs)*

5. **Frequency response**

Design Challenge

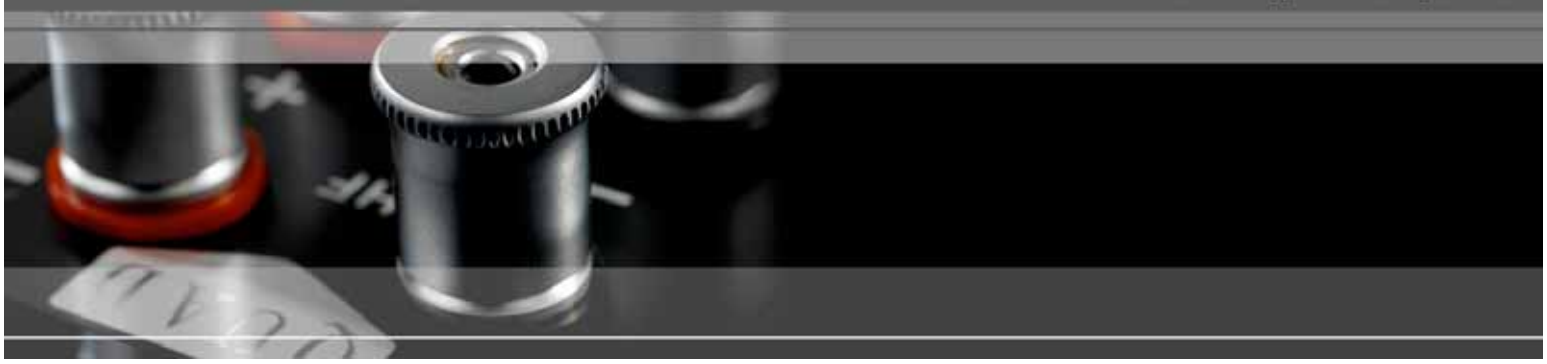
An important, but by no means the overriding, aspect of loudspeaker design is the frequency bandwidth it is capable of achieving. To achieve the same perceived amplitude of bass frequency as treble, a logarhythmically larger volume of air has to be moved. This requires either the use of a larger cone to move the air, or for the smaller cone to travel a greater distance. In the case of the latter, much more powerful magnet systems are required. As well as the force required to move the air, it also has to be borne in mind that the cone itself has a degree of inertia due to its inherent mass. The cone has to be effectively damped against over-movement. Other factors such as the port tube tuning arrangement and internal cabinet volume all dictate how easy or difficult it is for the bass cone to respond effectively to the frequency it is presented with.

At the other frequency extreme the problems are also those of mass, inertia and magnet strength. To be able to reach the very highest frequencies above 20kHz, the diaphragm need to be able to accelerate and decelerate 40,000 times per second or more.

Research now indicates that loudspeakers which have a response way beyond these traditionally understood to be the limits of human hearing (around 18kHz) have a subjective performance advantage. This is a result of their improved ability to follow complex waveforms at even high-frequencies.

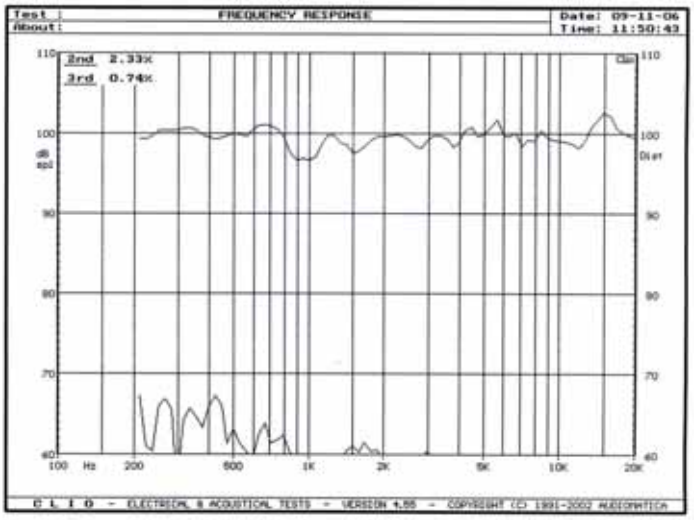
Solution

All of the L2 series cabinets are ported, with the smaller bookshelf models having a unique twin port arrangement. This allows the bass driver greater freedom of movement due to decreased internal pressure resistance, and is tuned to create a remarkably low frequency response in respect to the dimensions of the cabinet.



The long-throw Kevlar driver is capable of terrific dynamic attack, mounted on a strong spider suspension and sealed with a twin butyl-rubber roll-surround. The cone itself is manufactured in-house from a bi-direction Kevlar weave – extremely rigid and linear in motion even with large-scale dynamic pieces.

A brand new tweeter has been developed for the L2 range, featuring a new Aluminium voice coil. This is capable of higher power handling and has better thermal properties. The Neodymium 'Rare-earth' magnets employed are almost twice as strong as those used in the previous L-series range. The stronger field the voice coil sits in means it responds much faster to the music signal and explains the exceptional detail and high-frequency response the new L2 series are capable of – well beyond the traditionally accepted range of human audibility.

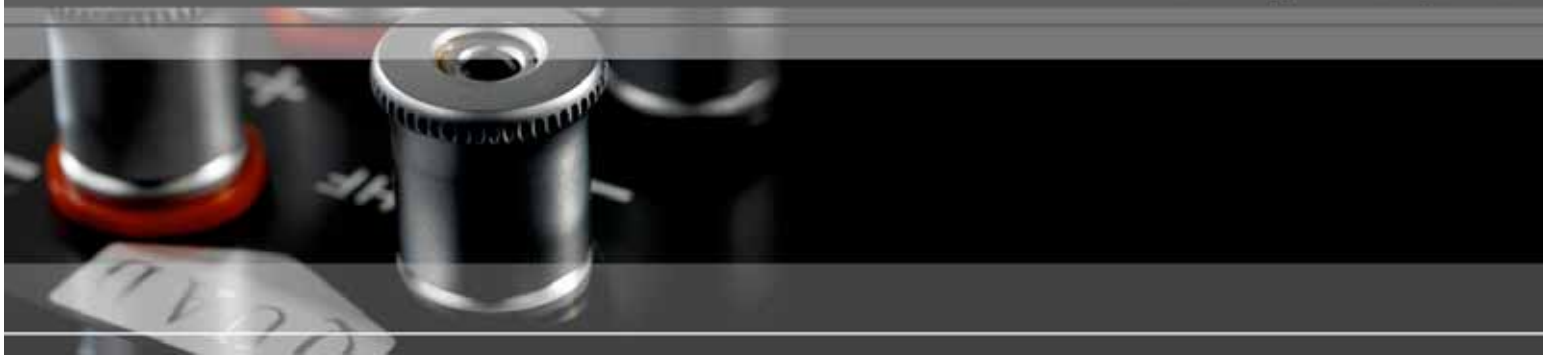



6. **Dynamic Range**

Design Challenge

As well as frequency range, each loudspeaker will have a maximum possible dynamic range – the difference between the smallest and largest wave amplitude possible. This is a direct function of how much air it is possible to move and how strong the magnet system is to push this air.

Whilst many loudspeakers are capable of impressive macro-dynamics – when the amplitude is push high and very dynamic pieces of music are played, it is a question of control and refinement as to how the loudspeaker performs in terms of 'micro-dynamics' – the subtle nuances and finer detail that can be lost in larger loudspeaker systems.



Solution

The powerful magnet systems in the Quad L2 series pack a terrific punch - enough, so that even at bass frequencies where large volumes of air have to be moved, they retain their composure – especially the large 21L2 and 22L2 models.

The real improvement in the L2 series though is in terms of the micro-dynamics. The new tweeter unit is capable of superlative detail with extended HF capability. This means it can track complex waveforms such as those produced from piano and violin, maintaining their tonal integrity for a much more believable, natural performance.

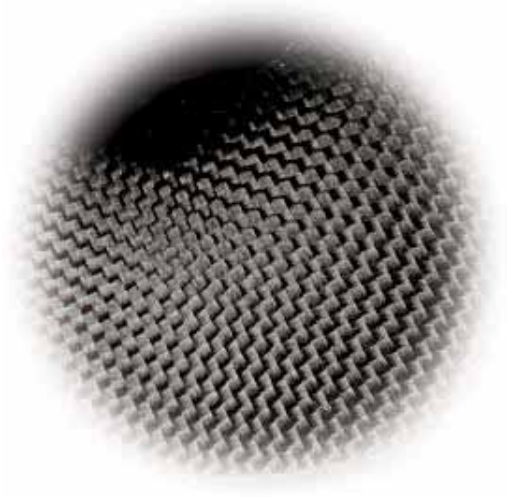
7. **Distortion**

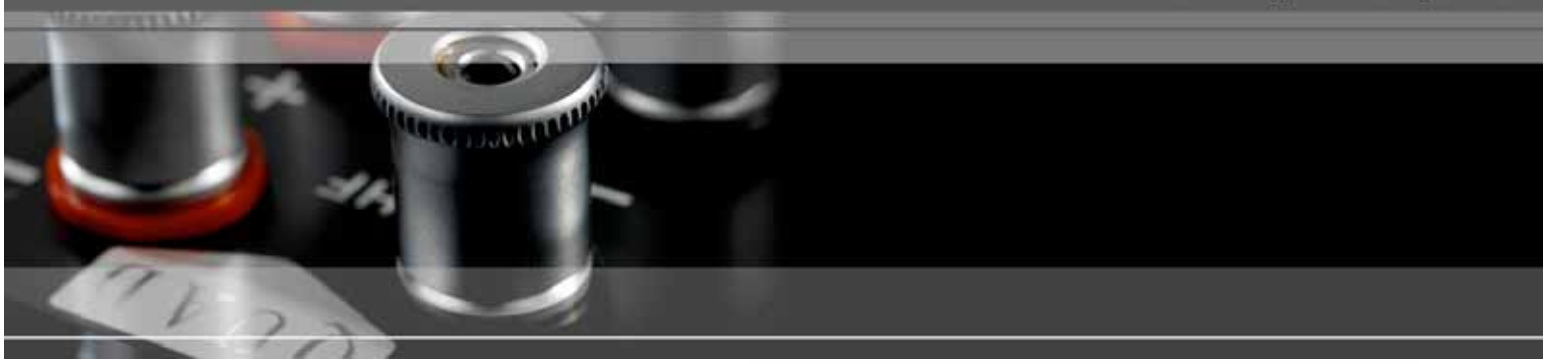
Design Challenge

There are many possible sources of distortion with a moving-coil loudspeaker system. All are notoriously hard to control and require careful engineering solutions and a thorough understanding of materials science to resolve. Typically one of the hardest sources of distortion to control is the cone diaphragm itself. The voice coil typically drives a small area in the middle of the cone, then relies on the stiffness of the cone to react to this impetus. This causes problems, because cone flex causes distortion; if the cone is too stiff, then transverse waves radiate through the cone and reflect back, causing distortion. The cone needs to be damped to prevent it 'ringing', but if over-damped, the cone suffers from inertia problems due to it being too heavy.

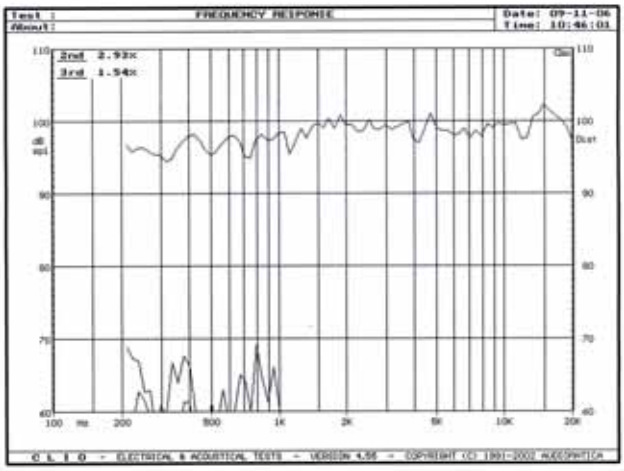
Solution

Our unique bi-directional Kevlar weave is a superb solution to the problems of cone distortion. Kevlar, of course, has incredible tensile strength, but very little structural rigidity, and needs to be woven in bundles of fibres to form a structure. This structure then needs to be resin impregnated to produce a cone of the appropriate stiffness. The resulting cone is very light and strong. Moreover, the nature





of our weave damps the transverse waves radiating from the voice coil when the cone moves, leading to a cleaner sound with much lower distortion. The graph to the right shows the distortion measurements for the centre channel through the most sensitive vocal range.




8. **Driver integration / Crossover design**

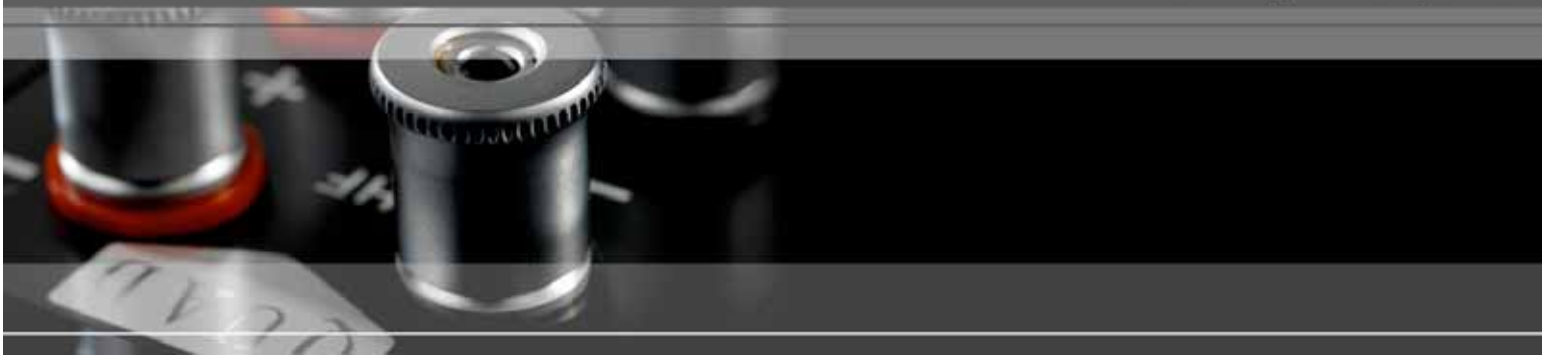
Design Challenge

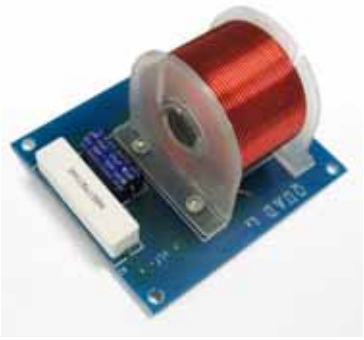
Due to the problems of cone inertia mentioned above, each drive unit typically only has a limited frequency response. Therefore, to achieve the desired bandwidth, multiple drivers are required. Whenever multiple drivers are used (usually a tweeter for high frequencies and a woofer for low frequencies), there is a frequency range in between them when both drive units are contributing to that frequency. This area is also typically in the region where the human ear is at its most sensitive. Constructive and destructive interference between the coincident waves from each of the drivers can cause phase problems. These problems are exacerbated because most manufacturers (even the larger ones) use bought-in drivers, rather than manufacturing themselves (a huge amount of investment is required to be able to produce your own drive units). In order to compensate for the inevitable miss-match between bought-in drivers, other loudspeaker manufacturers tend to try and correct these problems through the crossover, maybe using high-order crossovers (creating a faster crossover slope). That can compound these phase problems and create further frequency response problems leading to poor mid-range integration.

Solution

Quad is in an enviable position amongst loudspeaker manufacturers in having a factory capable of complete vertical integration which extends through the R&D process.

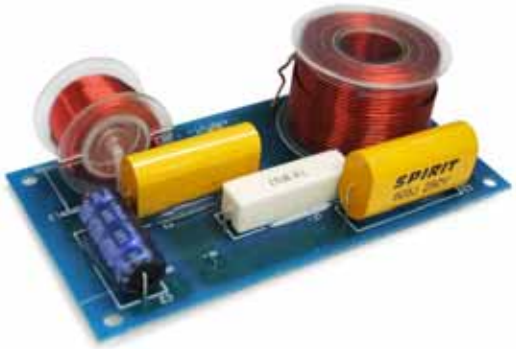
Every single chassis, cone, spider, magnet assembly, terminal, cabinet, crossover and even the internal wiring is made within our own four walls. This affords our





loudspeaker engineers remarkable freedom in design. They have the ability to design drive units which have natural roll-offs at particular frequency – very exacting performance parameters which can be defined at the outset – all of which contributes to us requiring only the very simplest low-order crossover.

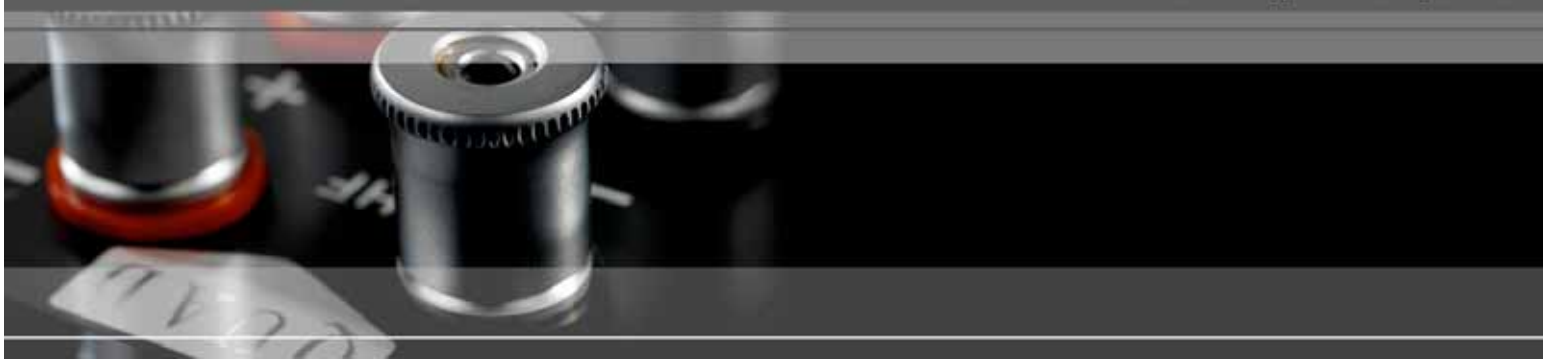
That said, the crossover on the L2 series is of audiophile quality in every respect. All components are mounted on glass-fibre circuit boards with large, non-interlacing tracks. Perfect layer, air-cored low-distortion inductors are wound on clear plastic bobbins and mounted in such a way as to virtually eliminate magnetic inter-modulation between components. All the capacitors used are metallised polypropylene low loss and low induction of the finest quality. The crossover is then wired internally to the drive units using exceptionally pure heavy gauge 'oxygen-free copper' internal wiring.




9. **Timing and rhythm**

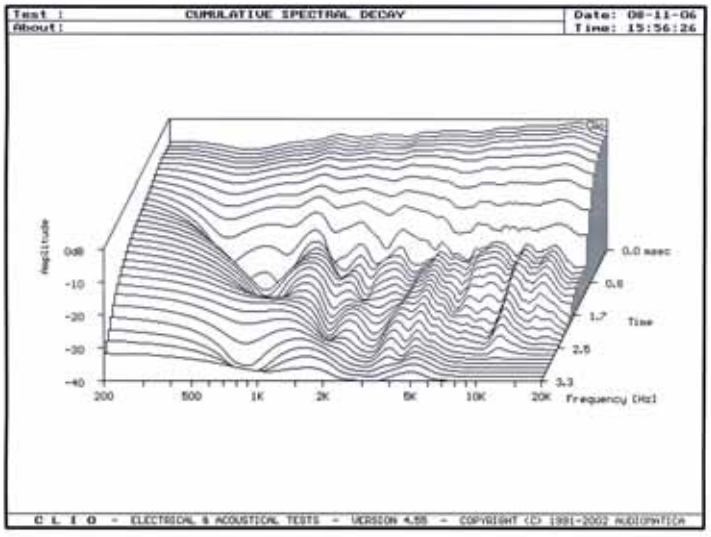
Design challenge

To achieve a response that is accurate and tracks the music signal precisely, a loudspeaker needs be able to react as a whole to the signal. Bass 'overhang' is unacceptable, but furthermore there are many other issues that affect the temporal integrity of a loudspeaker. One key contributor to temporal smearing of the mid-range is reflections from the bass-driver chassis itself. Most drive units are manufactured using either plastic or pressed steel chassis. This requires them to have quite wide legs and relatively small apertures between them. The rearward movement of the cone is reflected from such structures back through the cone, causing temporal smearing of the mid-range akin to the 'ghosting' effect seen on televisions when reflected signals occur.



Solution


Tracking a music signal precisely and accurately in the time domain requires a very clean and fast loudspeaker, free of complex reflections and interactions. A powerful tool for Quad in designing the L2 series has been our degree of vertical integration. Because we have complete freedom of design for our own drive unit chassis, and the ability to manufacture complex cast alloys into almost any shape we desire, we have engineered a cone which is robust, strong, light with one of the cleanest rear profiles of any chassis ever created. The chassis legs radiate from the centre uniformly and in such a way that even leg reflections are quickly dissipated within the cabinet. This has almost eliminated this common source of temporal smearing.

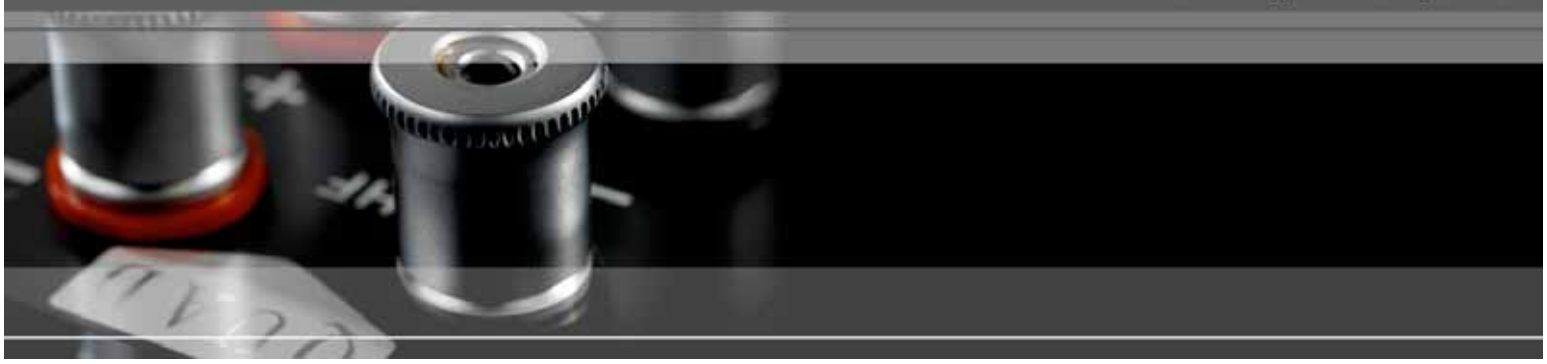



The powerful magnets in the bass and treble drive units keep tight control over any diaphragm inertia. The attached waterfall plot (*below*) from the L2 satellite speakers is a perfect example of how quickly and cleanly the drivers follow the decay from an impulse.

10. **Cabinet design**

Design Challenge

A cabinet around the drivers is a necessary evil of loudspeaker design and allows the forward wave to be less affected by the rearward travelling wave produced by



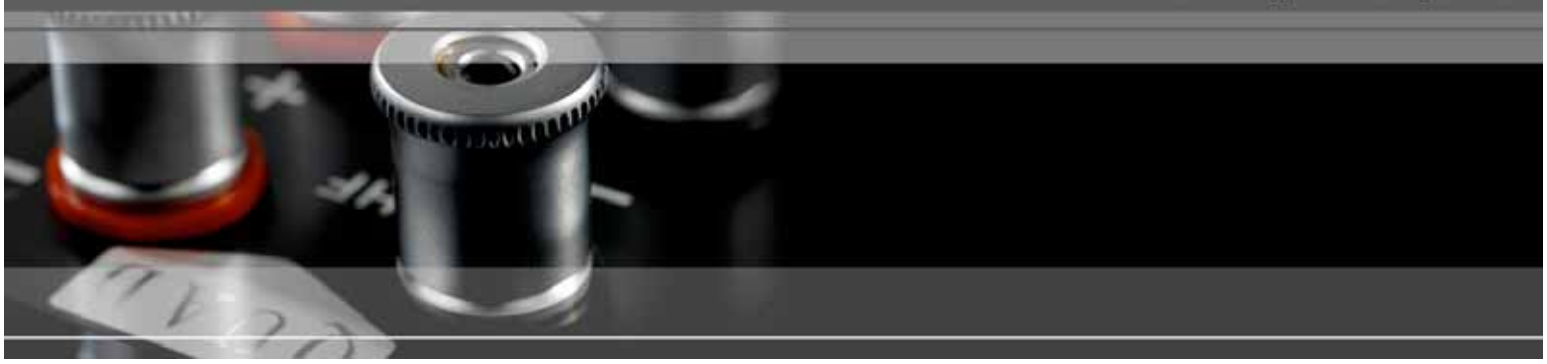
the cone movement. In all other respects however, the job of the acoustic engineer is to minimise the effect of the cabinet.

The problems are again, numerous. The cabinet can itself suffer from transverse waves, colouring the sound. The rearward waves travelling from the back of the cone can create standing waves reflected back and forward inside the cabinet, leading to slow and coloured bass. The internal volume needs to be maximised to allow the greatest bass extension, yet for a modern aesthetic, the smaller the loudspeaker is, the more acceptable it becomes for a domestic environment.

Solution

This was a particular challenge as we wanted to retain a very traditional aesthetic. The cabinet itself is manufactured from Starwood MDF – a very high grade, Eucalyptus based material, prized for its woodworking qualities and low internal resonance.

This choice of material coupled with additional internal bracing, designed to randomise the internal reflections and thus prevent standing waves from forming significantly reduces cabinet colouration and resonance.



Appendix 1

## ► Quad 12L

Horizontal Directivity