DALI EPIKORE 11

WHITE PAPER

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EVO-K HYBRID TWEETER

Introduction

DALI celebrates its 40th anniversary in 2023, and to mark the anniversary we are proud to introduce the EPIKORE 11. The EPIKORE 11 is a new, high-end audiophile loudspeaker that bridges the gap between the DALI EPICON and the DALI KORE, but also opens its own fresh chapter in the DALI story. In addition to introducing new concepts and refinements in loudspeaker engineering, the EPIKORE 11 takes all that DALI has learned in 40 years and invests it into extraordinary electro-acoustic performance and audio realism, combined with luxurious craftsmanship. The EPIKORE 11 creates an exceptional visual and musical experience.

The EPIKORE 11 is the natural evolution of our acclaimed DALI EPICON series but benefits enormously also from lessons learned and technologies conceived during the development of our DALI KORE flagship loudspeaker launched in 2022. When we developed and launched the DALI KORE, its role was not only to introduce new technologies and techniques, but also to define a benchmark for the level of sound quality achievable in the home and set groundbreaking standards for low distortion loudspeaker design.

The EPIKORE 11 is the next high-end audiophile stereo loudspeaker launch since the DALI KORE and it is fundamentally informed not only by the electro-acoustics of the KORE, but also its philosophy of striving to optimise every last technical opportunity for ultimate sound performance. The EPIKORE follows in the footsteps of the DALI KORE extending the ambition of establishing DALI in the luxury, ultra-high-end category.

In the following pages we will describe the design, engineering, technologies and manufacture of the EPIKORE 11 and how they are combined to create uniquely exceptional music reproduction.

DALI EPIKORE 11

System and Design Fundamentals

The EPIKORE 11 is a substantial, floorstanding, audiophile loudspeaker comprising a slim and elegant curved enclosure and no less than seven drivers: four 200 mm (8 in) bass drivers, a 165 mm (6.5 in) midrange driver, a 35 mm (1.4 in) dome tweeter and a 10 mm x 55 mm (0.4 x 2.2 in) ribbon tweeter. The EPIKORE 11 is configured as a four-and-a-half way system.

The EPIKORE 11 is configured such that each pair of DALI in-house designed and manufactured bass drivers works in its own reflex loaded enclosure, vented to the rear via generously dimensioned and angled continuous flare reflex ports. The similarly in-house designed and manufactured EPIKORE 11 midrange driver and EVO-K Hybrid Tweeter are housed in a separate module comprising an aluminium die-cast front panel. Behind the die-casting is a sealed 6 litre rear enclosure for the midrange driver. The EVO-K Hybrid Tweeter, located just above the midrange driver, is identical to the one developed for and employed in the DALI KORE flagship loudspeaker.

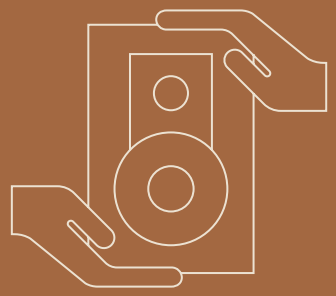
The EPIKORE 11 industrial design and aesthetic style takes its lead from the visual language developed for the DALI KORE. It combines sinuous curves with sharply defined delineation of its individual elements to present an elegant and purposeful aesthetic. Its finish incorporates sumptuously lacquered veneers and luxuriously tactile surface finishes that express the finest design and manufacturing quality.

THE EIGHT DALI SOUND DESIGN PRINCIPLES

The primary function of any loudspeaker is to convert the electrical signal from the amplifier into a realistic, undistorted and uncoloured audio experience.

DALI loudspeakers are designed in accordance with our fundamental acoustic and electro-acoustic principles and are founded in a strong belief that an authentic and honest sound reproduction will get you even closer to the full impact of a live music experience.

These principles are found in every DALI loudspeaker, closely intertwined and extremely dependent on each other. Even the smallest of changes can improve the final result, ultimately creating a musical, harmonic, informative and entertaining experience, in honour of the artists and out of the respect for our audience.



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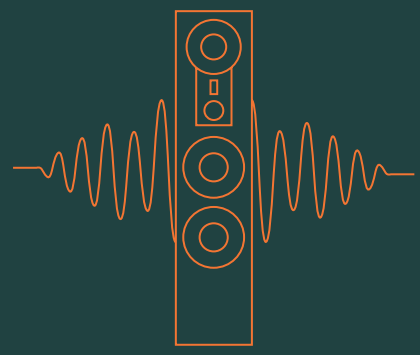
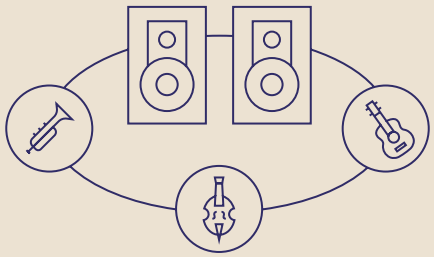
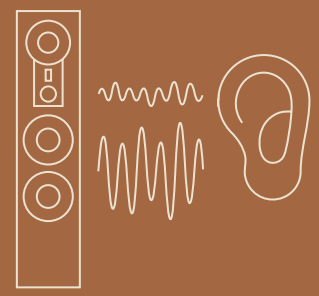


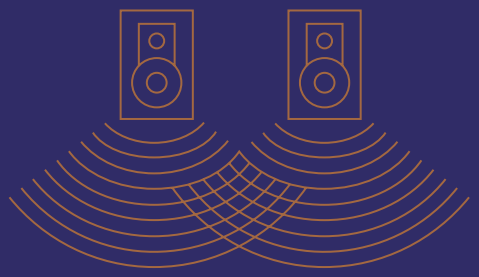
LOW-LOSS



HOLOGRAPHIC SOUND IMAGING

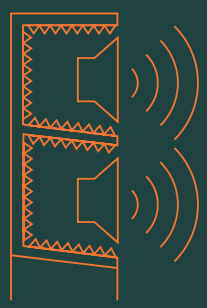


TIME COHERENCE

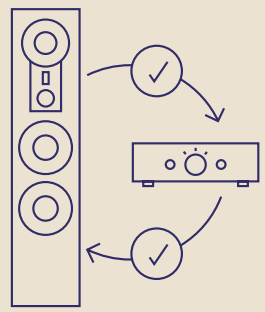


WIDE DISPERSION

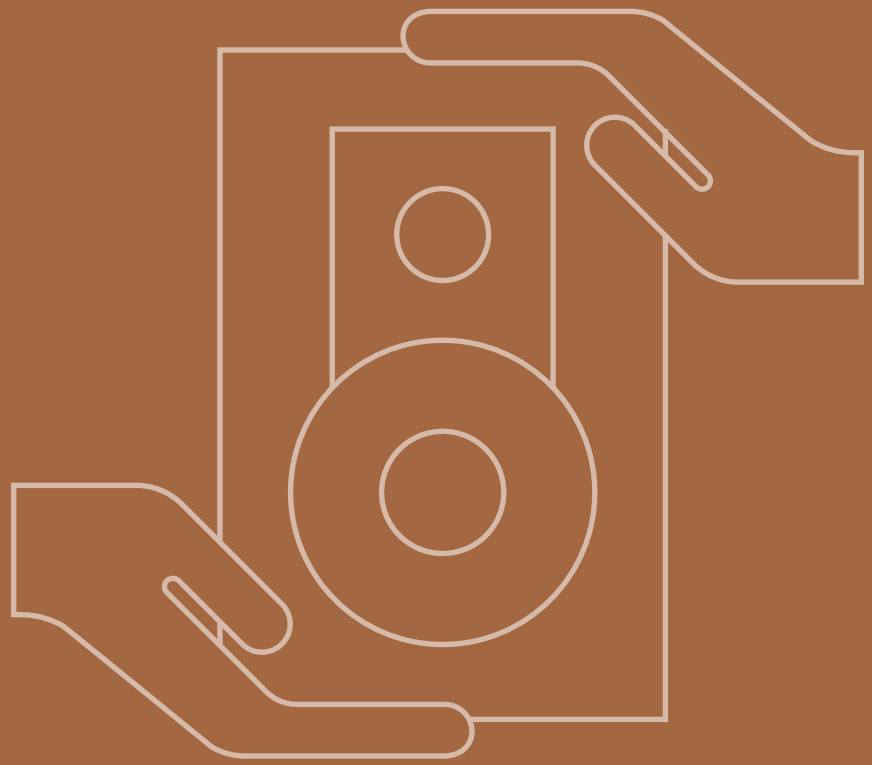
CLARITY



LOW RESONANCE CABINET



AMPLIFIER OPTIMISED



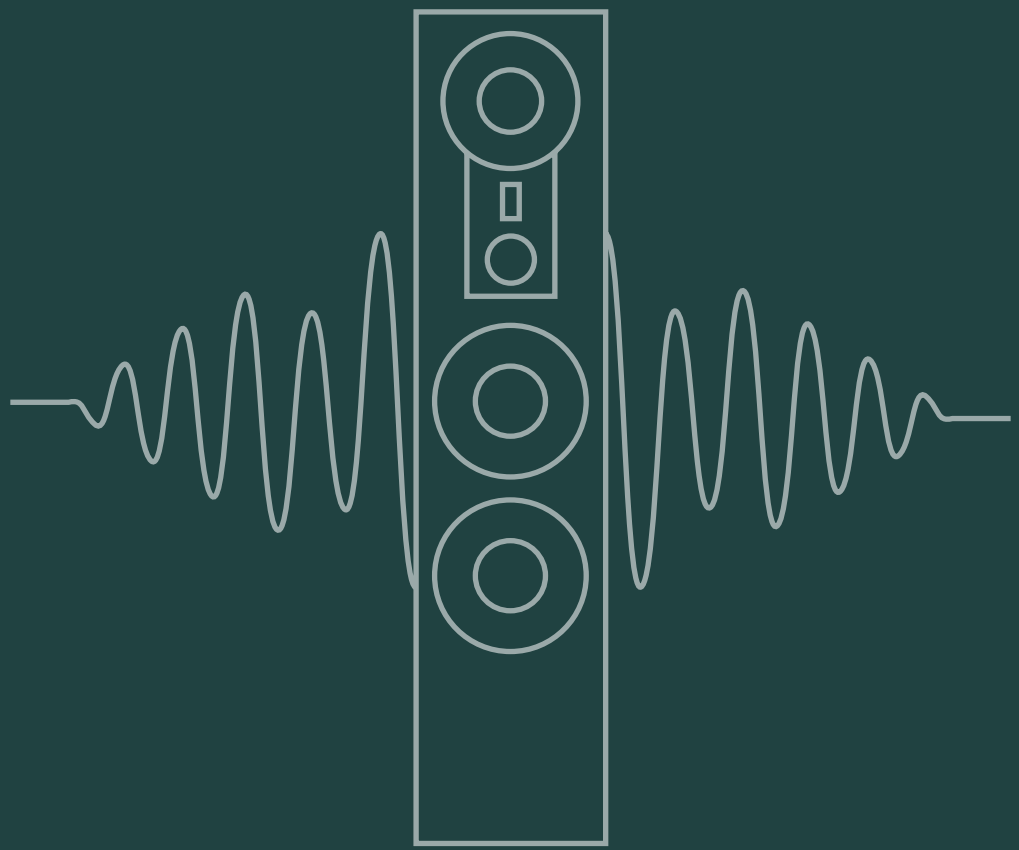
INDIVIDUALLY CRAFTED

Every DALI loudspeaker is individually assembled and rigorously tested before it leaves our production line.

It's a production line we constantly look to improve in order to maintain our reputation for producing the highest quality loudspeakers, each one made by highly skilled employees at individual, parallel assembly stations. Using sophisticated test equipment, they evaluate every single loudspeaker in terms of electrical impedance, acoustic frequency response, various types of distortion and "rub & buzz", SPL/sensitivity and absolute polarity. The reference curves are calibrated from the finally approved prototype.

Hand-assembled from the fitting of the cabinet to the final electro-acoustic testing, each and every DALI loudspeaker is finally approved and signed by the person who assembles it.

By employing the best features from both industrial manufacturing and individual craftsmanship, we ensure that every loudspeaker is of the same quality – from the very first to the very last item manufactured.



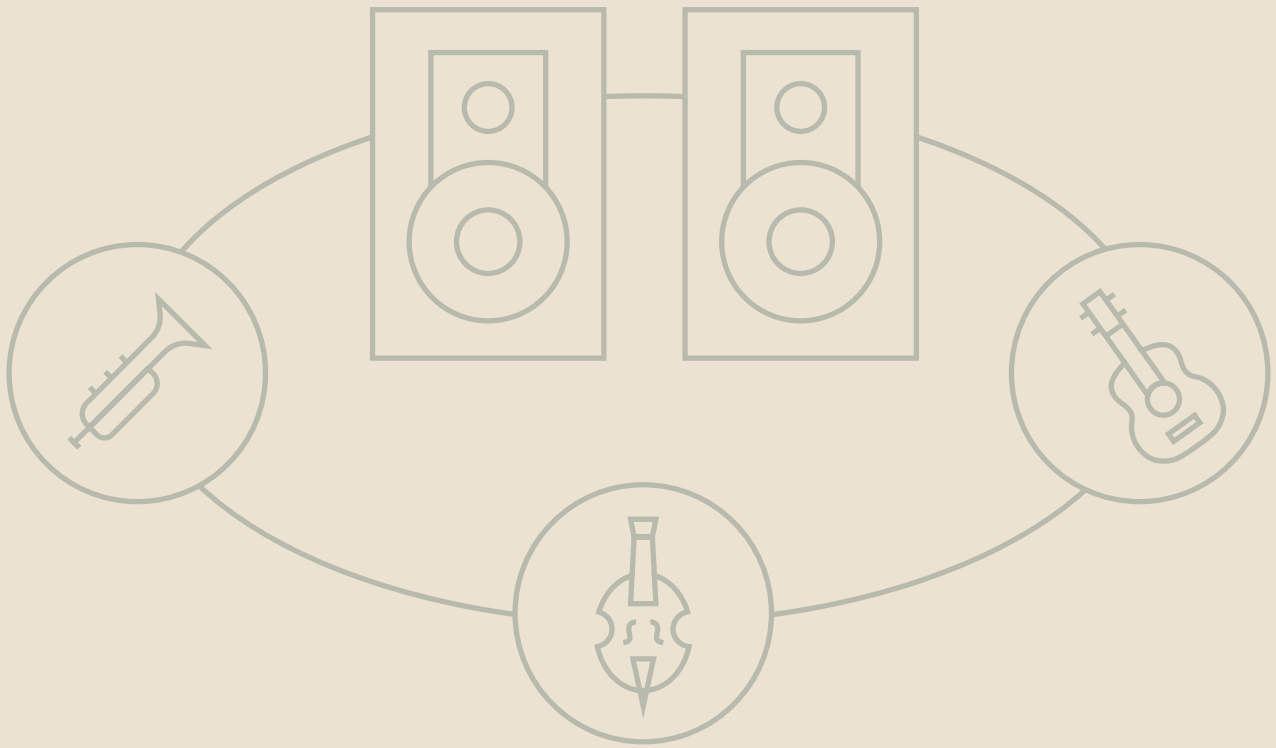
LOW-LOSS

The selection of low-loss materials and decisions on construction details are fundamental in any DALI loudspeaker. From the placement of bass ports, design of crossover, cone and suspension materials, to the voice-coil and magnet motor system which includes DALI's patented SMC technology in several loudspeaker ranges.

By prioritising low-loss we are able to create an optimum working environment for the voice-coil. Reducing sluggishness created by an unyielding rubber surround and by using lightweight materials.

We significantly manage to reduce the mechanical distortion by dramatically lowering hysteresis and eddy currents by replacing iron with SMC (Soft Magnetic Compound) in the magnet motor. Lowering the mechanical and magneto-mechanical loss is also particularly important since these sources for distortion always are of a non-linear nature.

With a very low mechanical loss, the most fragile sound details, even at very low listening levels, are preserved. This is the best way to obtain ultimate transparency and "liveliness" from reproduced loudspeaker sound.



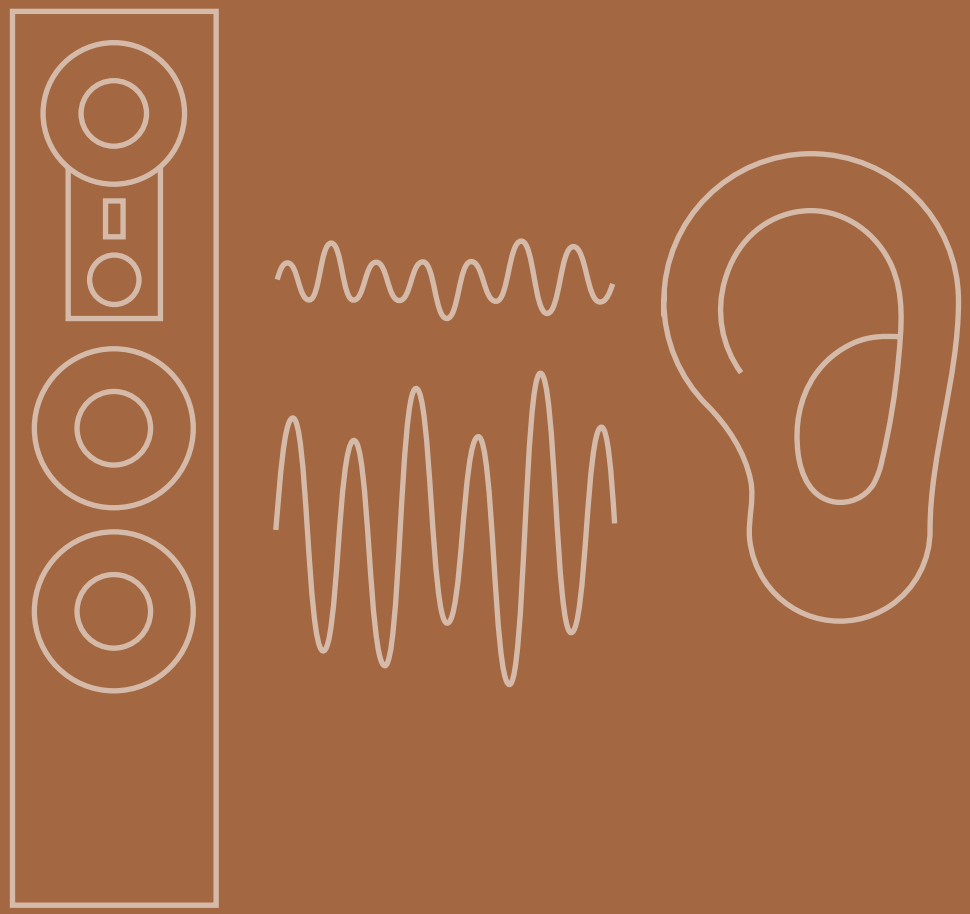
HOLOGRAPHIC SOUND IMAGING

Creating a believable soundstage is all about reproducing every single detail in the audio signal, at the right time. To do this, it's crucial to minimise mechanical distortion, dynamic compression and signal loss in the crossover. The goal is to make the loudspeaker "disappear," and reproduce the sound exactly as the artist intended.

Reproducing an accurate three-dimensionality requires that every part of a loudspeaker works perfectly together to create a fluently stitched together signal in both the time and frequency domain. DALI's time coherence and low-loss technologies ensure a transparent, holographic, three-dimensional soundstage. For us, the key is choosing our building materials with great care, making sure that no signal is lost or changed on its way through the loudspeaker system.

The coated wood fibre materials in our woofers guarantee an extremely controlled, ultra-rigid cone that reacts with incredible speed resulting in a fine resolution of the low-level details and the subtlest musical nuances. We also constantly push the boundaries for magnet system design by integrating non-electrically conductive materials, such as our patented Soft Magnetic Compound. By integrating non-electrically conductive materials in the magnet motor system, we are able to reduce the non-linear mechanical distortion and compression significantly.

By using only DALI designed and custom built drivers, the need for frequency correction in the crossover is minimised. This enables us to design a carefully matched crossover, which together with carefully selected quality components, ensure that the signal loss is close to zero.



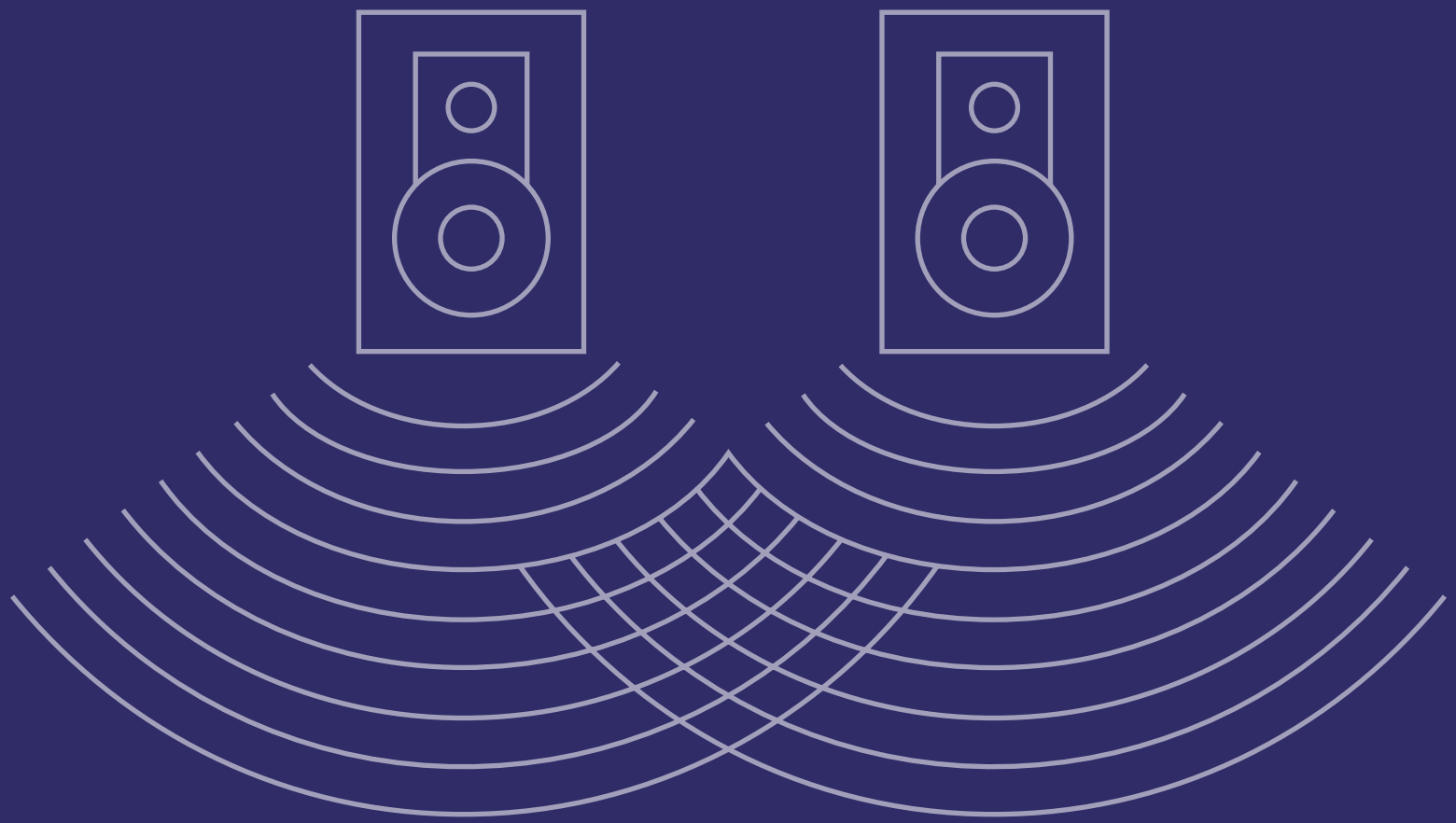
TIME COHERENCE

Ensuring perfect teamwork between the individual drivers in a loudspeaker is the key to deliver a realistic transient response and 3D sound image. Timing across the drivers and a perfectly optimised handover from driver to driver is the basis for a lifelike and believable audio experience.

All drivers in every single DALI loudspeaker are time aligned to ensure every aspect of the music signal arrives to the ear at the right time.

A specifically designed frequency response, sound dispersion, baffle placement and the enclosure, ensure an optimum total response and roll-off as well as phase response profile, simplifying the requirement for crossover corrections significantly. If not executed carefully, the use of bass ports may result in a slow one-note bass performance.

However, tuned correctly, the bass port will support and by that relieve the driver at its self-resonance point, removing the motion strain on the driver to keep it tight and well-timed. By optimising the placement of the bass ports within the cabinet and the chamber the driver is working in, the driver agility and airflow is maximised. The result is a low acoustic resistance and optimum transient response, which in turn is the base for a natural and lively sound reproduction.



WIDE DISPERSION

The enjoyment of music and movies is paramount to DALI and we design our loudspeakers to give listeners the best possible experience in all areas of the room.

By optimising the audio signal for off-axis distribution, the signal reaching your ear directly and the signal reflected in the room surfaces will have a coherent balancing. This results in a consistent high-quality sound, not only across a much wider listening area, but also increasing the area of the “sweet spot” where the audience can experience the best possible sound. It also offers greater freedom and flexibility in positioning the loudspeakers.

The uniform dispersion over a wide range of listening angles ensures a smooth, reliable energy distribution within the listening room, another crucial factor for coherent and well-balanced tonality.

CLARITY

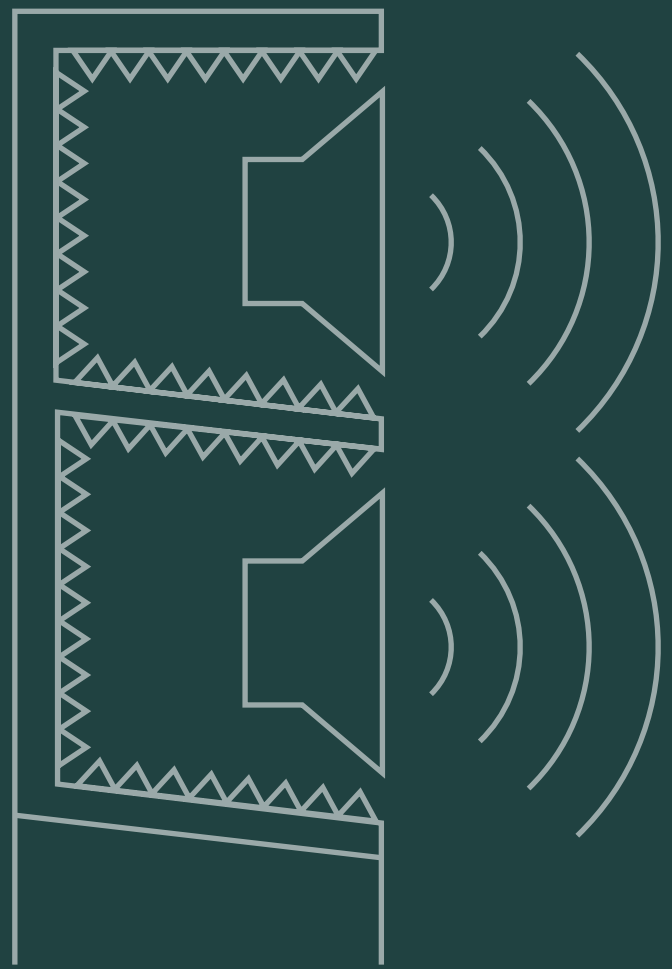
Clarity in the audio signal is obtained by low loss of information in combination with a smooth and seamless reproduction in both the time and frequency domain. To retain such seamlessness, the integration of the drivers in the loudspeaker has to be perfect.

The success of integrating two or more “overlapping” drivers depends on numerous combinations of elements, which can only be achieved by carefully optimising the driver not only for perfect frequency response in its main working area, but also at its outer limits. This attention to the roll-off area is one of the key points to creating an absolutely coherent sound experience.

The human hearing is particularly sensitive in the mid-frequency range – centred around 3,000 Hz. This frequency area is also where most bass/ midrange drivers must hand over the signal rendering to the tweeter’s frequency range. Any distortion, signal dip or poor integration of phase behaviour between the two contributors, or any other sort of colouration within this crucial area, will notably degrade the audio clarity.

Even if you get everything else right in the loudspeaker’s audio design, a misstep in the wide overlap zone within the midrange frequencies will significantly reduce the possibility of perceiving the midrange reproduction as seamless, and consequently also ruin the three-dimensionality of the soundstage.

DALI strives for perfect integration and a flawless balance between all levels, phase relations and other parts involved in creating the complete frequency spectrum. Getting this right, without any quirks in the frequency phase and time response, we know will present the listener with an open window of detailed and truthful musical experience.



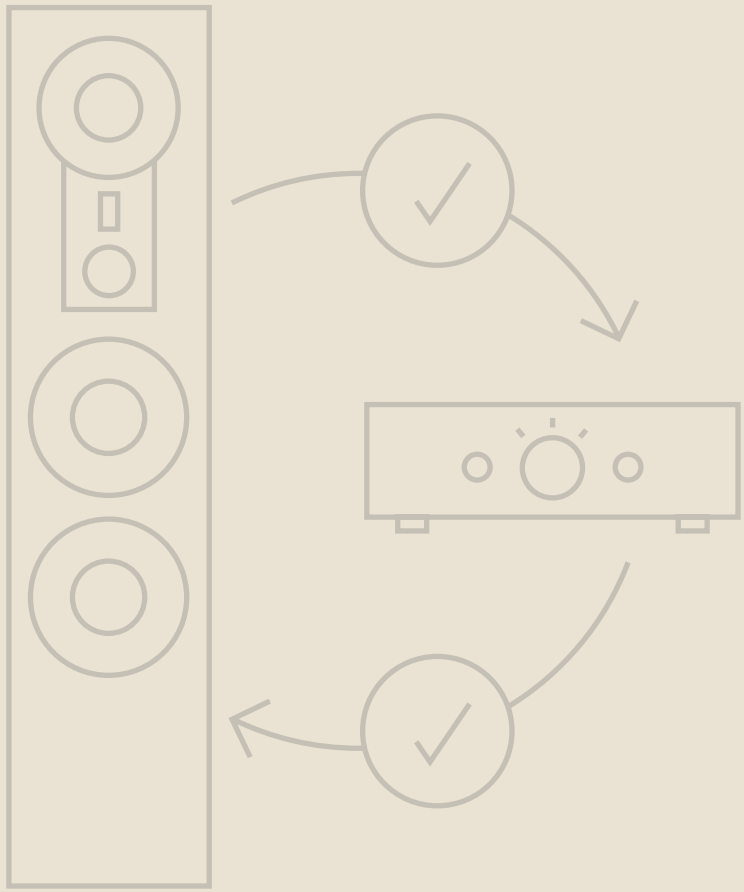
LOW RESONANCE CABINET

As a loudspeaker cabinet surface can be up to 40 times larger than the surface area of the drivers, vibrations can add unwanted sound output, mixing the sound from the drivers and colouring and masking the end result. The cabinet has two very important acoustic functions; supplying the optimum volume for each driver to work in, and acting as a solid acoustic/mechanical “grounding” for the drivers.

The motion of a driver affects both the outside structure of the cabinet and the airflow within it, causing resonance and standing waves. Designing the cabinet to reduce the effects of the driver, outside as well as inside the cabinet is a fine balancing act. With too little damping and, stiffening, resonance and standing waves will make the cabinet “sing” with the audio signal, colouring the overall presentation. With too much dampening and internal bracing the airflow inside the cabinet will be hampered and the audio signal will be flat, slow and the sound reproduction will not deliver the much wanted live dynamics.

Adding too much bracing and stiffening will also present a risk of resonances being inevitably shifting upwards in frequency where the human ear is typically more sensitive. Acknowledging that the optimal balance will leave behind some resonance, the structure of the cabinet must ensure that resonance is kept at low frequencies as this will have a minimal effect on the audio reproduction (rather than “shifting” them upwards and into the hypersensitive midrange region).

Resonances in the midrange frequencies are significantly more audible than resonances at lower frequencies. Therefore all DALI cabinets are designed to minimise any resonance and standing waves – and to keep unavoidable resonances within the lower frequency range with low “Q” values. With cabinets optimised this way, the audio reproduction is less coloured and more “musical” and as responsive as possible.



AMPLIFIER OPTIMISED

The aim is always to ensure a stable load for the amplifier for maximum audio performance. When listening to a loudspeaker, you are in fact hearing the amplifier as much as the loudspeaker itself. The goal for us is to create the optimal working conditions for the amplifier when driving the loudspeaker load. The linear impedance and minimal phase shift of our loudspeakers improves the quality of sound from the amplifier.

This stable and linear environment is crucial for quality sound. Fluctuating impedance loads tend to destabilise the amplifier's internal feedback loops, and the driving amplifier will experience this unbalance more and more as the frequency gets higher. An uneven impedance curve at higher frequencies makes the amplifier less "relaxed" which will reduce the sound quality, e.g. the perceived "musicality" from the amplifier. The purpose of the amplifier, as well as the loudspeaker, is to reproduce the signal exactly as it is without adding or subtracting anything. If the impedance of the loudspeaker changes at different frequencies, the amplifier encounters constantly varying load, making it much harder for the amplifier to define the signal/music accurately.

The proprietary DALI driver and crossover design ensures optimum working conditions for the amplifier by delivering a linear impedance environment, with minimal phase shifting which helps any amplifier sound at its best – and by that the performance of the entire sound system.

SMC Generation 2

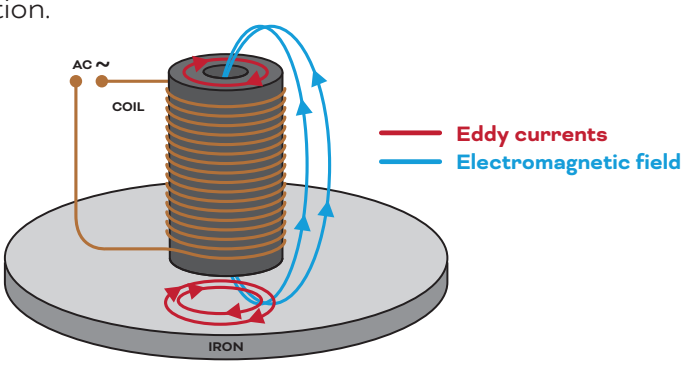
Both the EPIKORE 11 bass and midrange drivers incorporate magnet systems comprising a magnetised ferrite ring capped with steel top and back-plates. And within the centre of their voice-coils, attached to their back plates, is a pole-piece manufactured from patented DALI SMC Gen-2 material. Furthermore, an inner radial region of their top-plates, closest to the magnet gap, also employs SMC Gen-2, to ensure that the parts closest to the voice-coil are free of magnetic and electrically conductive iron. Iron is a material often used in magnetic motor systems as it has fantastic magnetic properties, but unfortunately also has a downside of electrical conductivity, which leads to eddy currents that hinder the free movement of the voice-coil and increase overall mechanical loss in the driver system.

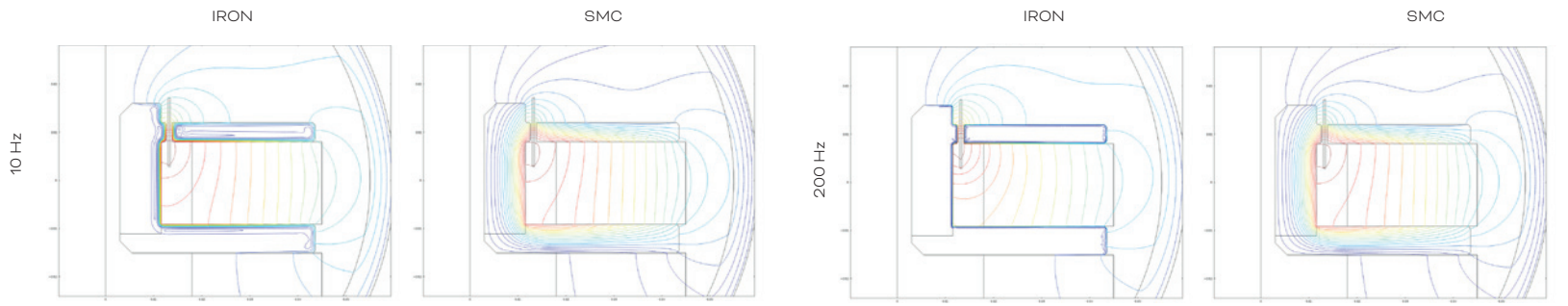
SMC Gen-2 is a coated, granular magnet material that can be formed to almost any shape and has many advantages when used in driver magnet systems. SMC's unusual combination of very high magnetic permeability and very low electrical conductivity (approximately 1/10,000th of iron), is exactly what is required for a driver motor system and results in a significant reduction of electro-acoustic distortion.

The Gen-2 version of SMC, first introduced in the DALI KORE bass and midrange drivers, offers significantly enhanced characteristics, especially at high magnetic flux densities and larger pole-piece cross-sectional areas. Compared to the low electrical conductivity of the first generation SMC material, SMC Gen-2 conductivity is further reduced by 2.5 times. As a result it has approximately 1/25,000th the electrical conductivity of iron.

SMC works by minimising the formation of pole-piece and top-plate eddy currents – or put another way – it removes the destructive breaking effects of iron materials. In a traditional, electrically conductive pole-piece and top-plate, movement of the voice-coil creates eddy currents that generate a secondary magnetic field in the nearby iron. This has a breaking effect on the free movement of the voice-coil and thus distorts the music signal quite drastically. SMC reduces current distortion in the magnet system and is directly measurable. Current distortion is generated in the magnet system, before and after the speaker starts moving, and is typically high for conventional iron-based magnet systems. Typically, 0.5% or higher in the woofer's entire working area. By using SMC we can lower the current distortion in the driver. In addition to reducing distortion by minimising eddy currents however, SMC additionally improves linearity within the motor system by practically eliminating magnetic hysteresis effects, and also minimises the variation of voice-coil inductance with position. All these benefits produce a very significant subjective reduction of low-level detail masking and colouration.

In addition to the adoption of SMC Gen-2, the EPIKORE 11 bass and midrange drivers also employ strategically positioned conductive aluminium and copper shorting rings that serve further to linearise the driver's behaviour by reducing modulation of the magnetic flux around the voice-coil by the input signal. A further significant reduction in distortion and signal loss results; and not only distortion, but the ugly and ear fatiguing odd-order harmonic distortion that's so destructive of music reproduction.

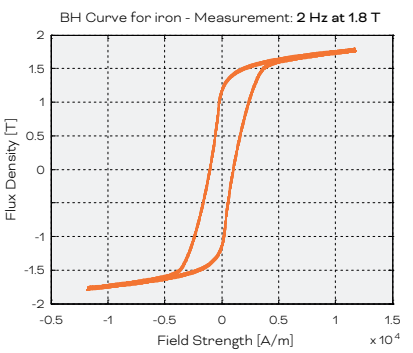


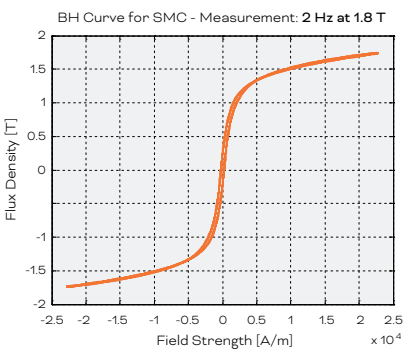


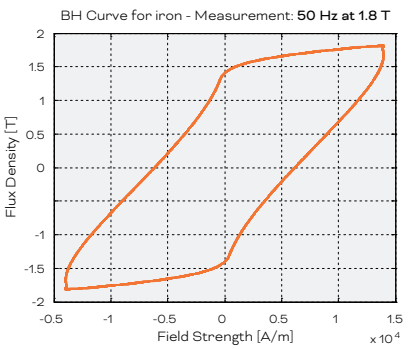
SMC Motor System Flux Lines

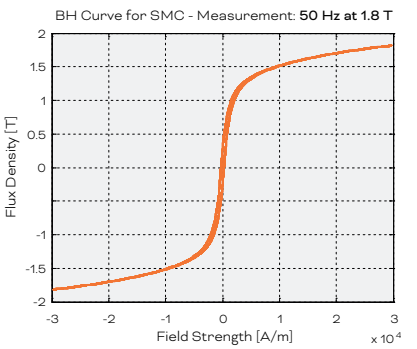
These section views of a typical driver magnet system illustrate the increase in magnetic flux density and linearity at 10 Hz and 200 Hz resulting from the use of SMC material in comparison to a traditional iron-based material. By using SMC instead of iron, the flux density and linearity doesn't change with frequency, which greatly reduces odd-order harmonics in the driver.

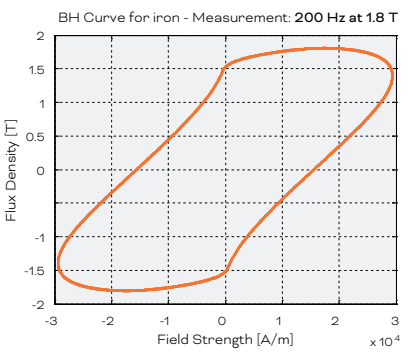
The SMC version is also significantly less influenced by the current in the voice-coil, which reduces the distortion from current generated flux variations.

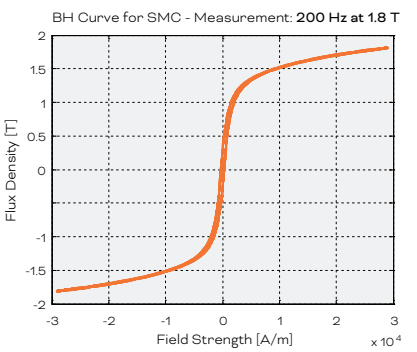






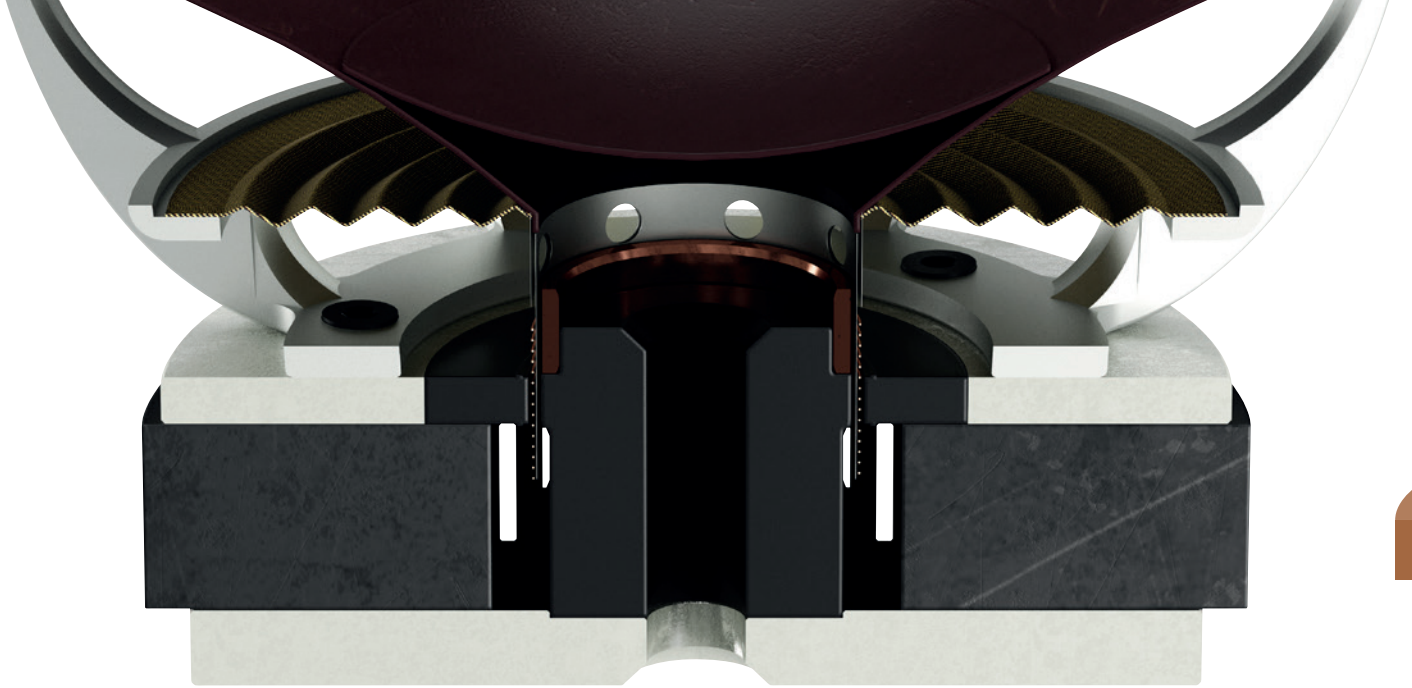


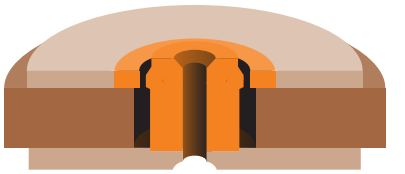




Hysteresis

Hysteresis is a characteristic displayed by many materials that results in variation of behaviour with the reverse direction of an action. An example might be a spring that is stiffer in compression than extension. In some magnetic materials, hysteresis leads to differences in magnetisation and de-magnetisation characteristics. In conventional iron-based loudspeaker magnet systems, this causes significant distortion. In motor systems incorporating strategically located SMC elements, however, hysteresis is almost completely eradicated. The illustrations to the left compare the hysteresis magnetisation curves of conventional and SMC-equipped magnet systems at different frequencies.





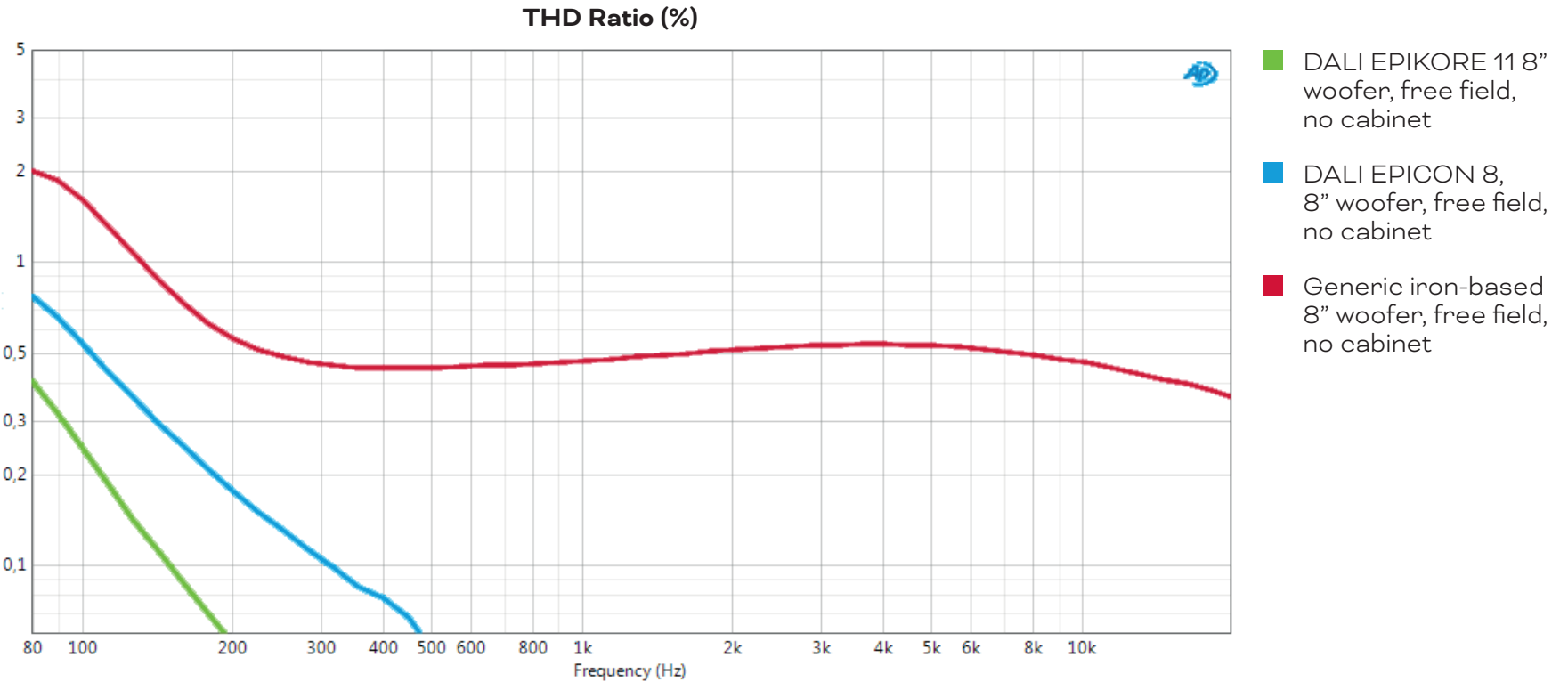
SMC – Gen 2

The graph below shows a current distortion (THD %) measurement of the EPIKORE 11 Woofer (— green) and an EPICON 8 woofer (— cyan) compared to a generic iron-based driver (— red).

Current distortion is generated in the magnet system, before and after the loudspeaker starts moving, and is typically high for conventional iron-based magnet systems. Typically, 0.5% or higher in the woofer's entire working area.

By using SMC we can lower the current distortion drastically in the driver, as shown on the graph. Up to 10 times (20 dB) lower current distortion than any iron-based driver.

By using the new and improved SMC Gen-2 material along with redesigned aluminium shortening rings, the EPIKORE 11 woofer has approximately 2 times (6 dB) lower current distortion than the, already exceptionally good, EPICON 8 woofer.

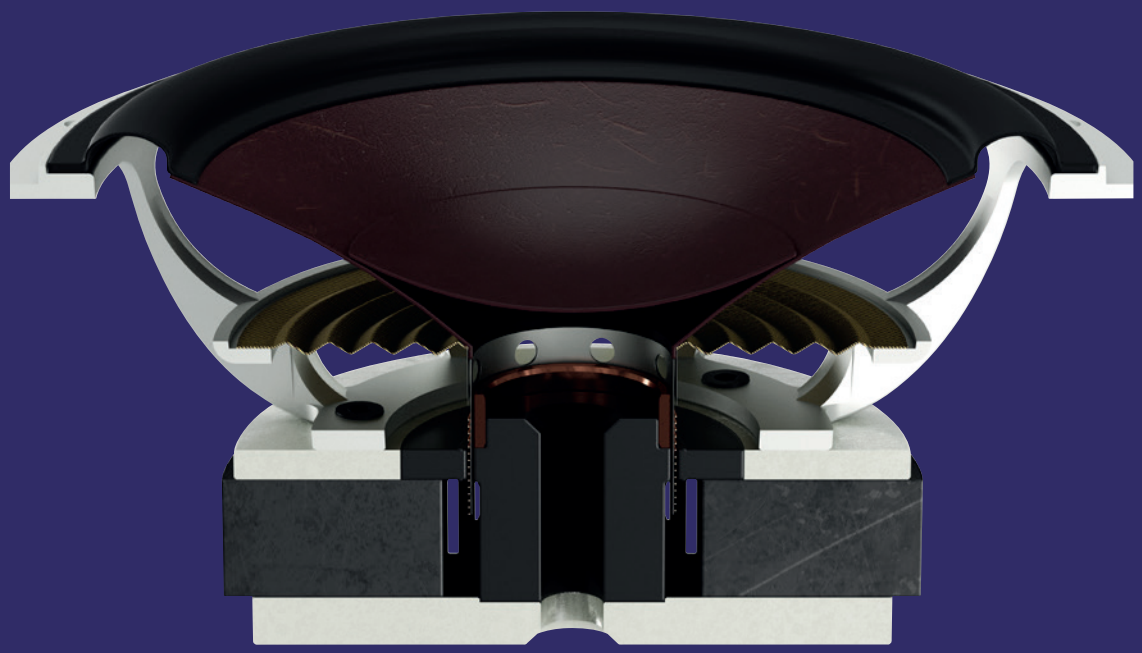


DALI EPIKORE 11

Bass Drivers and Low Frequency System

The EPIKORE 11 is, like the DALI KORE, designed to offer the apparently unlimited and distortion-free low frequency bandwidth and volume that are so important in defining true high performance music reproduction. The key to this kind of performance, and the overarching DALI philosophy, is linearity and low loss. Every element of the EPIKORE 11 bass driver is directed towards these principles.

To that end, the EPIKORE 11 bass driver is engineered both for immense speed of response and dynamic signal tracking, while at the same time generating minimal distortion – of any kind. The EPIKORE 11 bass driver is a completely new development of the similarly dimensioned DALI EPICON 8 driver and features a rigid yet well damped wood fibre and paper composite diaphragm combined with a highly flexible and generously dimensioned natural rubber-roll surround that allows unimpeded diaphragm dynamics. Also incorporated is a newly designed basket/chassis. Like the roll-surround, the driver suspension is specifically designed to optimise the linearity of its restoring force. The driver employs a massive ferrite magnet system in order to achieve very high flux density in its magnet gap, and both its vented pole-piece and inner top-plate region are manufactured from DALI's second generation SMC (Soft Magnetic Compound).



Titanium Voice-Coil Former

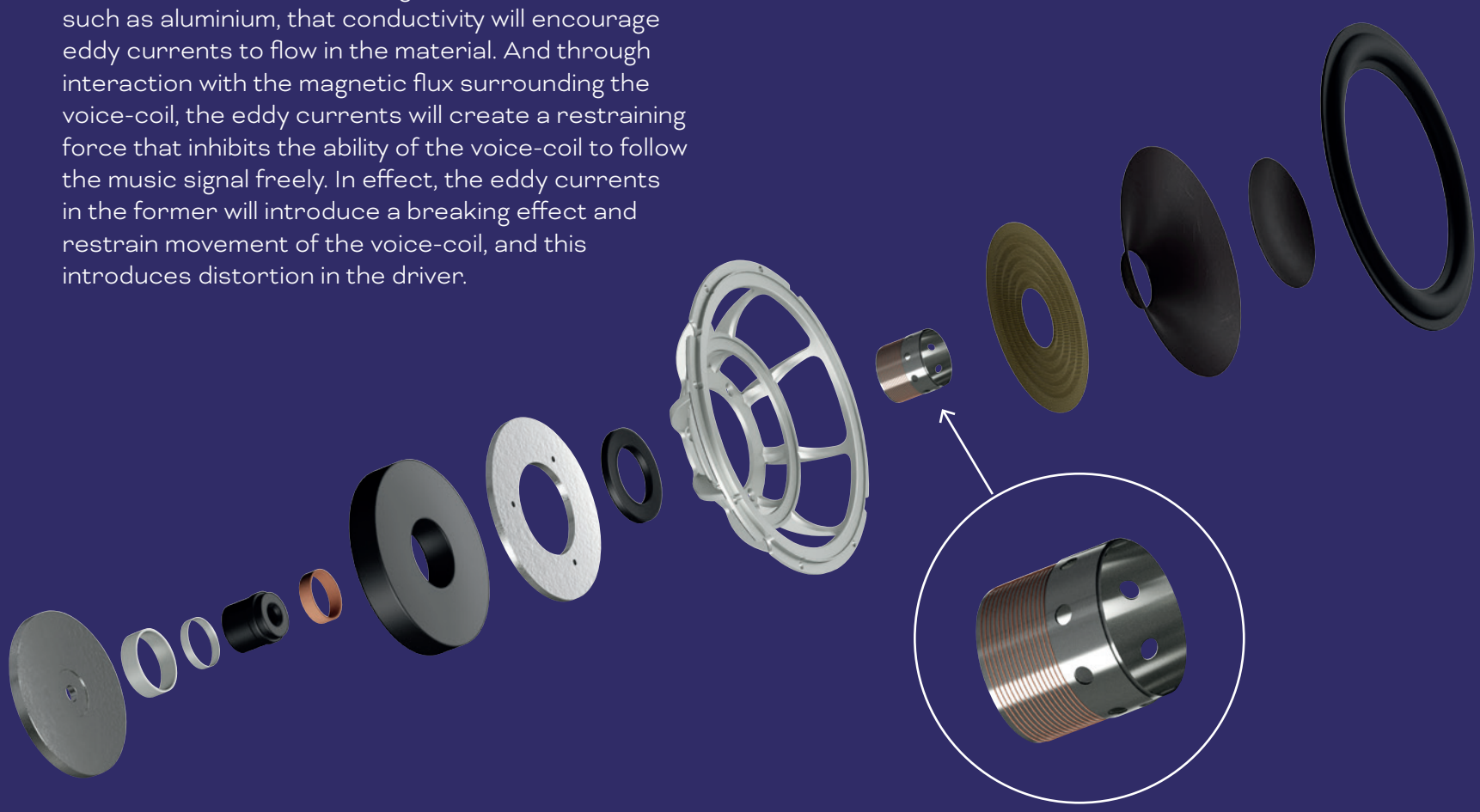
The primary new technology of the EPIKORE 11 bass driver, a technology borrowed from the DALI KORE research, is the new 38 mm (1.5 in) diameter titanium voice-coil former. The voice-coil former is traditionally a little regarded driver component, however its specific mechanical and electrical qualities can have a significant influence on driver performance.

Firstly, the voice-coil former creates the vital mechanical link between the voice-coil itself and the diaphragm. The voice-coil transforms signals in the electrical domain to mechanical movement; pushing and pulling the diaphragm back and forth in response to the music signal to generate acoustic energy. So unless a voice-coil former offers perfect rigidity, some musical information will be lost.

Secondly, if as is commonly the case, the voice-coil former is made from a strong electrical conductor such as aluminium, that conductivity will encourage eddy currents to flow in the material. And through interaction with the magnetic flux surrounding the voice-coil, the eddy currents will create a restraining force that inhibits the ability of the voice-coil to follow the music signal freely. In effect, the eddy currents in the former will introduce a breaking effect and restrain movement of the voice-coil, and this introduces distortion in the driver.

The conventional alternatives to aluminium voice-coil formers are most often glass-fibre or polyimide film materials. Both are electrically non-conducting, so are immune to the eddy current issue, however neither offers the degree of mechanical rigidity required for the EPIKORE 11 bass driver. Being twice as rigid as aluminium however, titanium does meet the required voice-coil former rigidity, and being almost 20 times less conductive, eddy currents are reduced to insignificant levels.

A further benefit of the titanium voice-coil former is that its increased rigidity enables larger ventilation holes to be placed in the region between the end of the voice-coil and the neck of the diaphragm. This increases airflow, helping both to control voice-coil temperature and minimise thermal compression, and to reduce the damping effect of air trapped beneath the diaphragm dust cap. The voice-coil former is not often seen as a major player in the driver story, but in the EPIKORE 11 bass driver, it has a starring role.

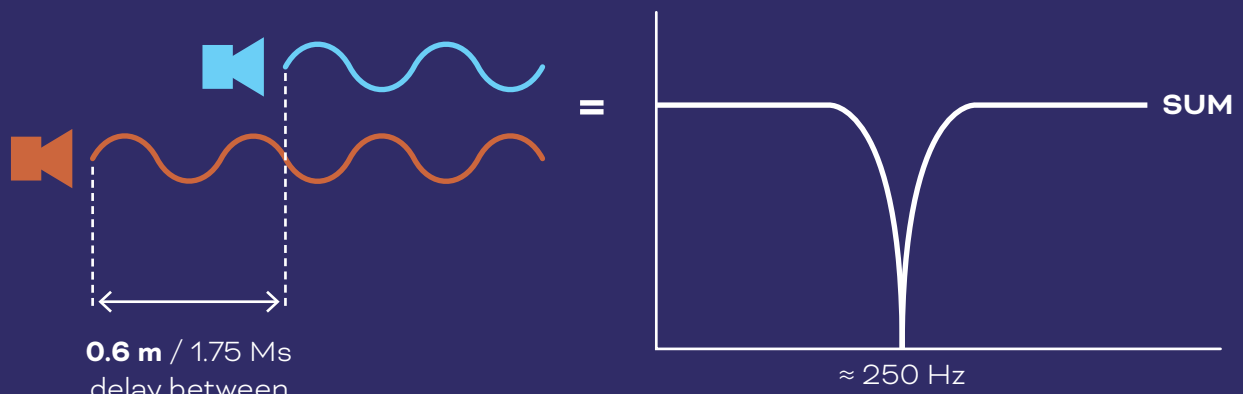


Eliminating Floor Reflections

The floor is the one room boundary that we really can't avoid, so the one inevitable and very well-defined sound reflection in any listening room is from the floor, which is normally also the first, sonically inseparable reflection. Consequently, a primary in-room challenge with the majority of hi-fi loudspeakers is sound cancellation at specific frequencies caused by the floor reflection interfering with the loudspeaker's direct sound. In typical hi-fi systems the floor reflection causes a cancellation loss in the 250-300 Hz band; a somewhat unfortunate area, right in the crucial transition between the fundamental and the overtone regions of many acoustic instruments and voices.

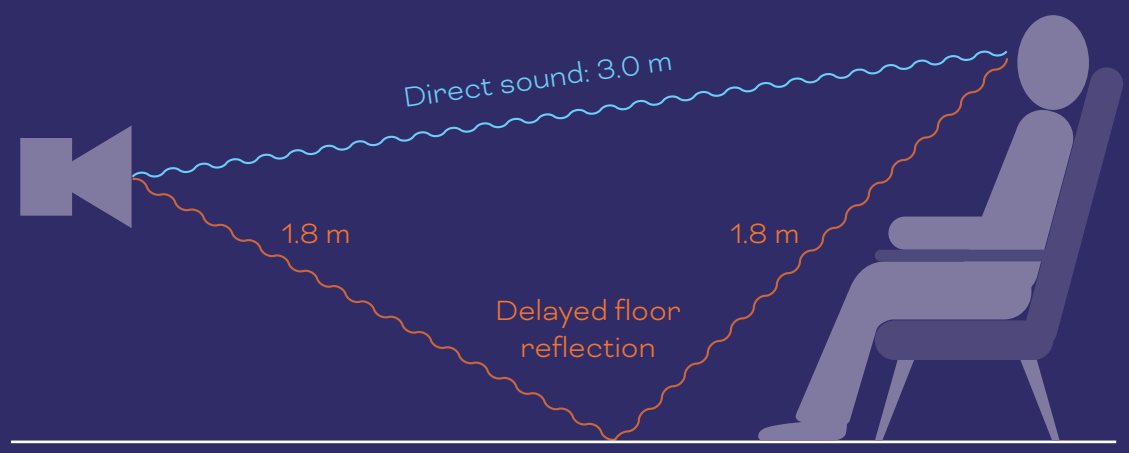
Due to the floor reflection loss being caused by cancellation, it is not possible to "fix" it with equalisation or room correction. However, through thoughtful bass driver configuration it is possible to minimise floor reflection.

Example 1:
Point source loudspeaker



0.6 m / 1.75 Ms delay between **direct sound** and **floor reflection**.

Cancellation of the two soundwaves causes a null at approx. 250Hz.



Floor Reflection Control

In multi-driver line-source loudspeakers (such as the DALI MegaLine, launched in 1996), the inherently constrained vertical dispersion of the line means that little acoustic energy is radiated downwards towards the floor – almost completely eliminating the floor reflection.

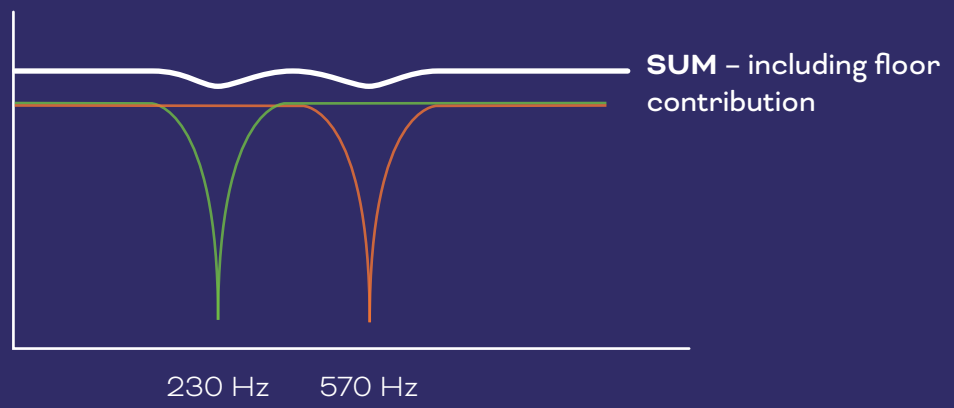
So inspired by the DALI MegaLine and line-source techniques generally, the EPIKORE 11 features Floor Reflection Control (FRC Technology); Two pairs of bass drivers, spaced apart and on separated crossover taps. The acoustic centre of the upper pair is shifted backwards, right in the frequency area where the floor cancellation would occur.

This, combined with the physical spacing to the lower bass driver pair, "tilts" the composite bass driver wavefront (radiation lobe) upwards, away from the floor.

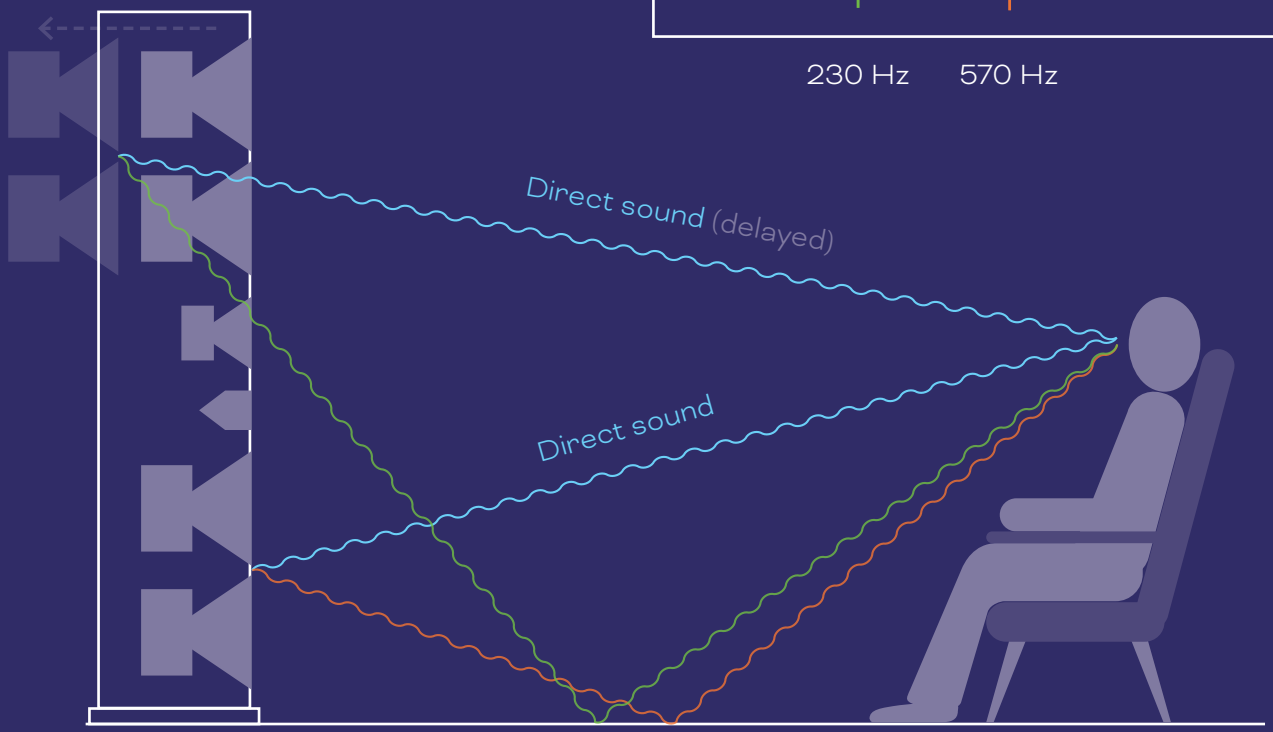
The effect is a significantly reduced floor reflection and an almost complete elimination of the usual cancellation in the critical 250-300 Hz band. The result is a more natural reproduction of timbre and tonality in the lower midrange – in any room with a floor!

Suppression of the floor reflection contributes to the EPIKORE 11's ability to reproduce all kinds of music with the least possible bias or colouration, and make it more true to the naturally harmonic texture of sounds found in live instrument performances.

Example 2:
EPIKORE 11 with Floor Reflection Control



The acoustic centre of the upper pair is shifted backwards, right in the frequency area where the floor cancellation would occur.



The two floor reflections are out of phase, which results in the floor reflections being nearly eliminated.

EPIKORE 11: Bass Performance

Each pair of bass drivers works into a 64 Litre bass reflex enclosure, with reflex ports venting to the rear. The ports are internally located very close to the rear face of the drivers in order to minimise low frequency propagation time (the delay between the rear of the driver to the entrance of the bass port), and are generously flared at their internal entrance and exit. The flaring in fact continues throughout the entire port length, resulting in a 'Continuous Flare' architecture that has no straight lines. Continuous Flare both ensures the greatest possible laminar port airflow and minimises the possibility of port "organ pipe" resonance. The two ports exit at a central location on the rear spine of the enclosure sharing a complex and attractively profiled moulded exit flare component. The EPIKORE 11 reflex ports are tuned to an unusually low 24 Hz. The low tuning frequency ensures that the system maximum group delay is minimised and occurs well below the frequency band that is most important for subjective bass timing and dynamics.

Although the primary role of the EPIKORE 11 woofers is to reproduce low frequency information, they also have a significant influence at higher frequencies. The EPIKORE 11 woofers have extremely low distortion in their primary working band but are also designed to display great linearity at higher frequencies. In fact, while the woofers are rolled-off into the midrange at 370 Hz, they would have no problem extending towards 1 kHz without adding significant distortion or frequency response nonlinearities.

Designing woofers with these qualities ensures that their transition to the midrange is seamless and linear. This not only ensures the EPIKORE 11 displays perfect timing and dynamic agility in the woofer passband, but also that the low and mid-frequency bands blend perfectly; the minimal distortion and colouration of the woofer overtones integrating perfectly into the midrange band.

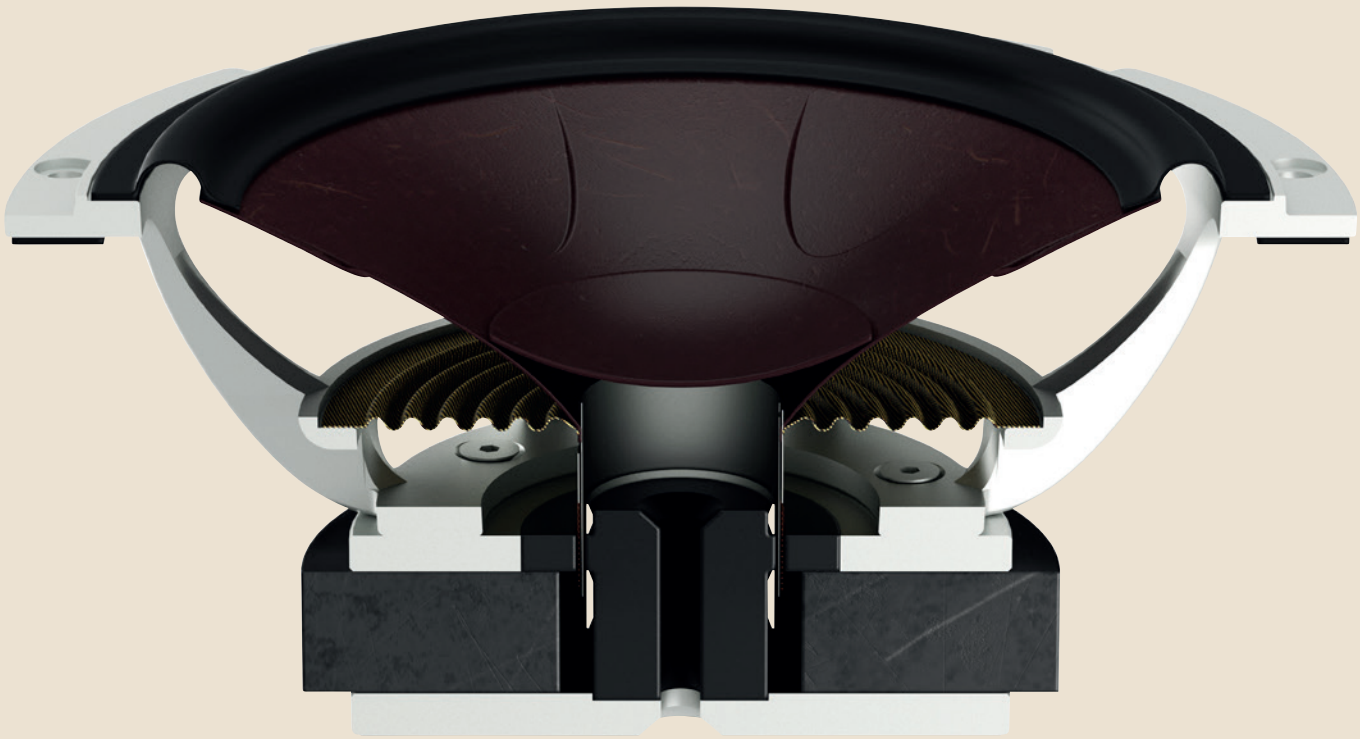
The EPIKORE 11 bass performance that results from the combination of drivers and enclosure is objectively second only to the DALI KORE in the entire history of DALI loudspeaker design. And subjectively, EPIKORE 11 bass sounds uncannily fast, tuneful and dynamic. It creates a flawless foundation for music or home theatre experiences.

DALI EPIKORE 11

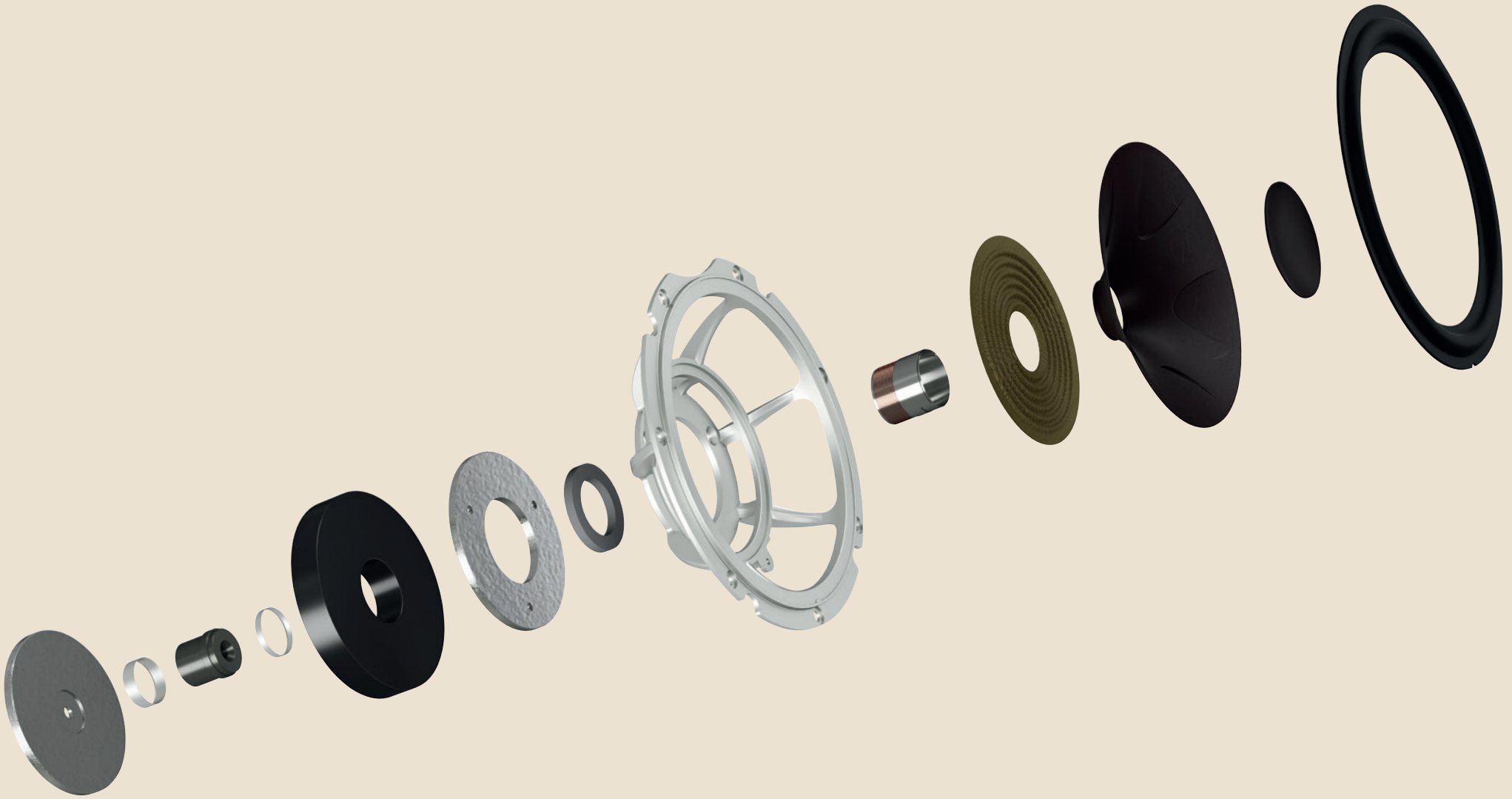
Midrange Driver

In the DALI KORE white paper paper, our CEO, Lars Worre wrote, “If you aspire to make the best loudspeaker, the midrange should be your priority. And the wider you can make the midrange, the better your loudspeaker will be.” We strive to express that philosophy in every DALI loudspeaker, but when the loudspeaker contains a dedicated midrange driver, as does the EPIKORE 11, the opportunities for its expression multiply.

The EPIKORE 11 midrange driver can trace its roots back to both the DALI KORE and the EPICON 8. Its EPICON 8 roots include its basic dimensions, chassis and magnet system, however the elements it borrows from the DALI KORE more significantly define its performance. In common with the DALI KORE midrange driver and the EPIKORE 11 bass drivers, the EPIKORE 11 midrange driver voice-coil former is made from titanium, and both its magnet system pole-piece and inner top-plate region are formed from SMC Gen-2, the latest generation of our SMC (Soft Magnetic Compound) material.. In addition to its voice-coil construction, the EPIKORE 11 midrange driver also borrows more from the DALI KORE; firstly, in using aluminium flux demodulation/inductance linearisation rings within its magnet system. Secondly, using the titanium voice-coil former. And finally in its embossed paper and wood fibre composite diaphragm.



Flux demodulation rings within loudspeaker drivers act to reduce distortion by nullifying the flux modulating effect of the moving voice-coil. As a voice-coil travels through the magnetic flux in response to the music signal, eddy currents generated in the iron-based components of the magnet system modulate the flux. The result is distortion. The role of an aluminium demodulating ring is to soak up the eddy current effect, but, being non-magnetic, the eddy currents have no knock-on flux modulation effect. Demodulation rings also act to reduce and stabilise overall voice-coil inductance, which in turn both aids crossover design and can extend a driver's high frequency bandwidth.



Paper and wood fibre composite diaphragm

The EPIKORE 11 midrange driver incorporates the DALI KORE developed paper and wood fibre composite diaphragm with its complex embossed geometric structure. The diaphragm displays all the benefits of the wood fibre technology well known from previous DALI designs: the wood fibres adding well-behaved and damped stiffness to help promote non-resonant break-up characteristics. The driver diaphragm also extends wood fibre technology by incorporating a physical structure that helps to further linearise response behaviour towards the upper end of the midrange bandwidth: it is embossed with a varying arrangement of lines and then carefully hand lacquered with a unique lacquer coating. The lacquer thickens in the embossed lines which helps control the diaphragm modes – suppressing them thanks to the irregular shape and prime number of five embossed patterns. This technique enables local variation of the stiffness-to-damping ratio across the diaphragm and enables ultra-fine tuning of diaphragm performance and subjective character. A technique developed for the DALI KORE that effectively dampens unwanted resonances on the midrange diaphragm without adding a single gram of weight. Thus, adhering to our Low Loss sound design principle.


DALI SMC DRIVER
EVO-K HYBRID TWEETER

DALI EPIKORE 11

Hybrid Tweeter

The EPIKORE 11 incorporates the same, remarkable EVO-K Hybrid Tweeter as the DALI KORE. It marks the ultimate expression of DALI's long-standing commitment to the benefits of combining dome and ribbon drivers to create hybrid units offering the best of both technologies, and is by far the best tweeter we have ever produced.

DALI Hybrid Tweeter technology has been the go-to choice for many DALI loudspeakers since it first featured in the DALI 700 in 1990. For the EVO-K, the Hybrid Tweeter technology has advanced considerably through the development of a completely new 35 mm diameter dome driver that incorporates an in-house-manufactured dome element.

EVO-K Soft Dome Tweeter

One of the advantages of the DALI EVO-K Hybrid Tweeter is that the ribbon element takes over for the final high frequency octaves from around 12.5 kHz to 34 kHz. This means that the dome element can be optimised to reproduce the band from the midrange crossover to the frequency band for which the ribbon is best suited. For the EVO-K, we chose to extend this principle by developing a significantly larger dome driver that would offer reduced distortion and, in particular, reduced power compression in the lower portion of its frequency band. The latter achieved without the need for ferrofluid in the motor system. Ferrofluid is a great thermal dissipater and also useful for centring the voice-coil in the magnet gap; a quality that some loudspeaker manufacturers love since it makes tweeter production easier. The drawback of ferrofluid however is that it has a viscous damping effect on voice-coil motion. And the faster the voice-coil moves, the more the ferrofluid damps the motion, presenting a nonlinear restraining effect on the voice-coil and creating distortion.

Removing the ferrofluid enhances the dome's ability to operate freely with the signal, as opposed to being restricted by the viscous damping effect of the ferrofluid oil. As well as offering approximately twice the radiating area of a 25 mm dome, a 35 mm dome has a significantly lower fundamental resonance. This is beneficial in terms of crossover design, as the resonance is located significantly further away from the high-pass filter frequency. The dome tweeter also features a large, bullet-shaped rear enclosure, made from cast aluminium, complete with fins that help to dissipate heat energy and minimise power compression. Damping material within the enclosure also absorbs and dissipates the dome's rear radiation. The subjective qualities of the EVO-K dome tweeter reflect the engineering effort and skill that we invested in its design. It is an exceptionally detailed tweeter yet naturally smooth in character, whatever the volume level or musical content and presents an effortless reproduction of the high frequencies.

EVO-K Ribbon Tweeter

The ribbon element of the EVO-K Hybrid Tweeter is an enhanced version of the DALI EPICON series driver. With a wide bandwidth and wide horizontal high-frequency dispersion, the ribbon element dovetails perfectly with the dome tweeter's natural tendency to become more directional towards the top end of its range. Gently rolled in above 10 kHz, the ribbon element makes a full contribution from around 12 kHz to well above 30 kHz. This ensures that the dispersion characteristics across the entire frequency band of the tweeter is consistent – something rarely achieved with conventional tweeter systems and a crucial element of DALI's Wide Dispersion Sound Design Principle.

Improvements over previous Hybrid Tweeter ribbon elements include a much more powerful, premium-grade Neodymium-Iron-Boron system. The revised ribbon element also incorporates a new rear-mounted aluminium heat sink and re-profiled waveguide, engineered to optimise dispersion and integration with the hybrid driver's 35 mm dome tweeter.

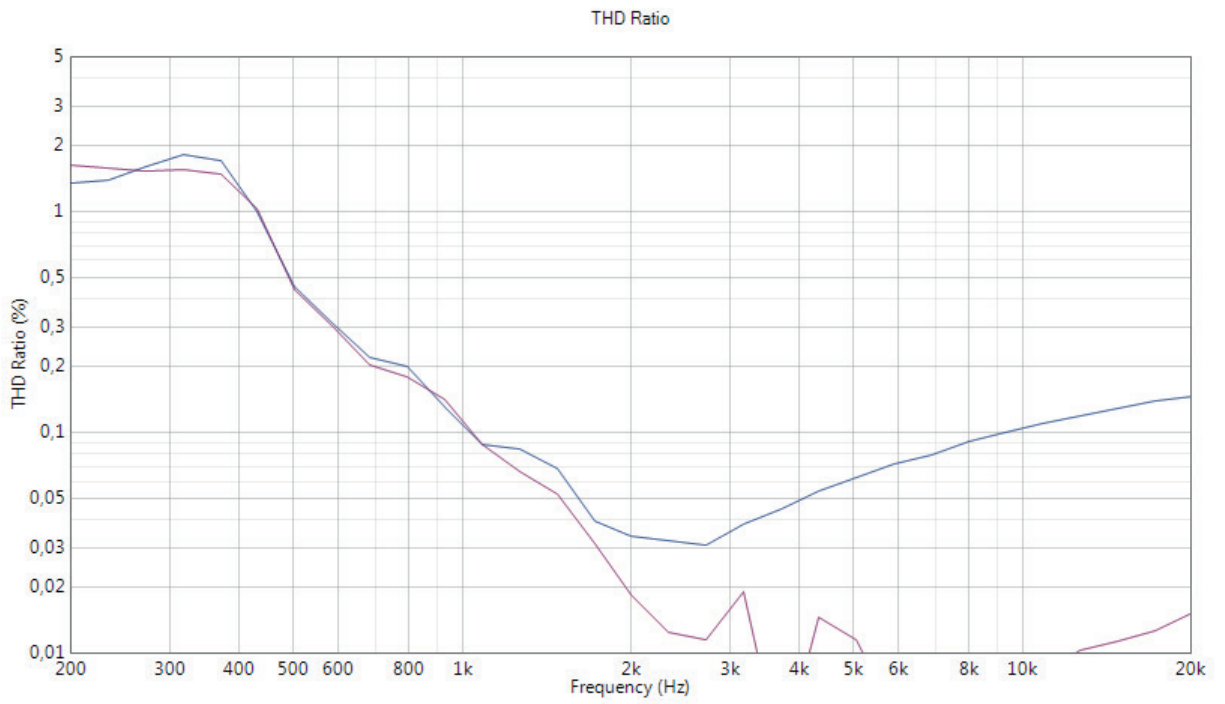
The new motor system, along with the re-profiled waveguide, results in an 8 dB increase in driver sensitivity and reduces both distortion and power compression.

Reducing voice-coil inductance and distortion

The inductance of a voice-coil can be reduced by fitting a ring or cap of conductive metal (usually aluminium or copper) on or over the pole-piece. Lower inductance results in increased output at the highest frequencies and can reduce nonlinearities.

Furthermore, alternating electromagnetic fields in the iron/steel components of driver magnet systems is a source of eddy currents, which also generates inevitable distortion. A properly designed copper cap on the dome tweeter pole-piece reduces such distortion by relocating the eddy currents to the cap, and because copper is non-magnetic, the eddy currents do not modulate the magnetic field around the voice-coil and consequently distortion is reduced, in some cases substantially. Distortion from eddy currents modulate the current in the driver's motor system, so it can be measured on the driver's input.

DALI EVO-K tweeter: Current distortion measurement



The graph illustrates the current distortion measurement of a an EVO-K dome tweeter, before (— Blue) and after (— Red) the addition of a copper pole-piece cap.

It shows a factor of ten (10 = 20dB) reduction in harmonic distortion through the tweeter frequency band from 2 kHz upwards when compared with a comparable “standard configuration” iron pole-piece solution.

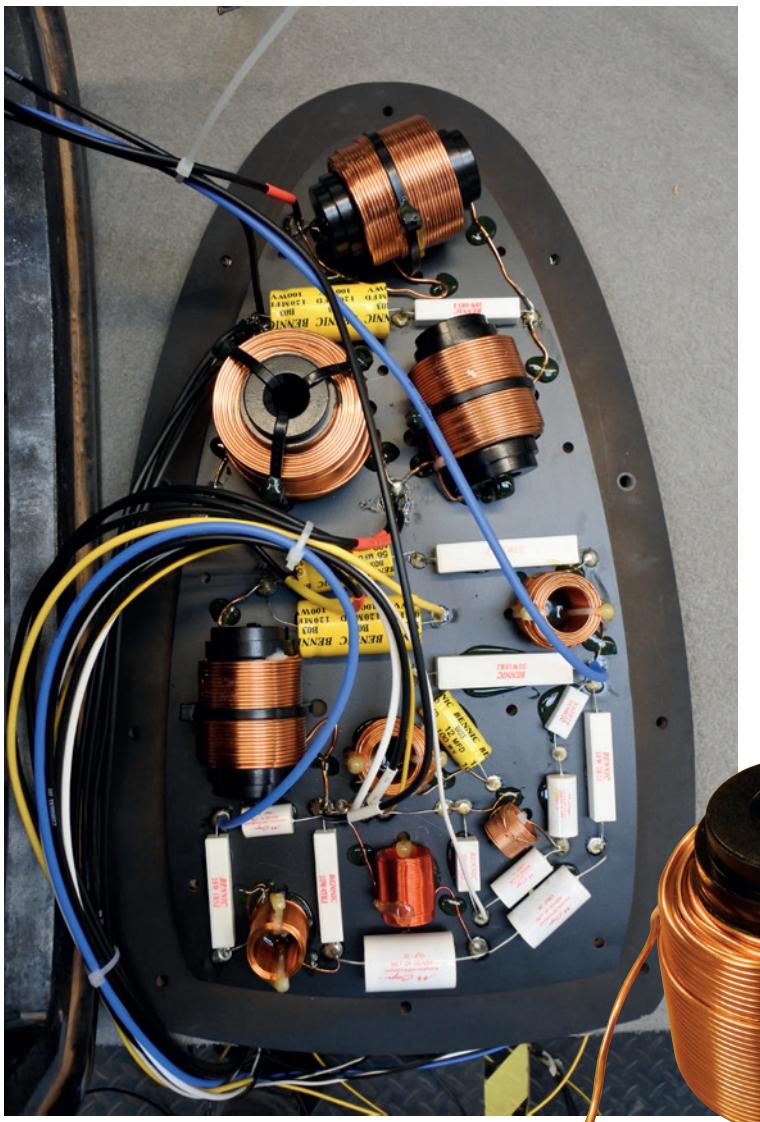
DALI EPIKORE 11

Crossover

Despite the apparent major difference between the DALI KORE and EPIKORE 11, with the EPIKORE 11 employing four bass drivers in comparison to the KORE's two, the fundamental acoustic architecture of the two systems is effectively similar. This is because, at low frequencies, the two units of each EPIKORE 11 bass driver pair are located close enough together to operate in acoustic terms as one composite unit. So, with the acoustic architecture of the DALI KORE and EPIKORE 11 being effectively similar, so too are the design challenges and solutions of their respective passive crossovers.

Passive crossover networks don't merely integrate the drivers but fundamentally influence the frequency response, time response, dispersion, detail, colouration and tonal balance of a loudspeaker. Their design is as much an art as it is a science. While the steady-state theories of electrical filter design are well established, passive filters feed drivers that vary dynamically in input impedance with both frequency and volume llevel, which adds immensely to the complexity.

Rather than conforming to any specific filter profile or topology, the EPIKORE 11 high-pass and low-pass filters are designed to achieve specific acoustic frequency and phase response targets. This target function approach to crossover design, which we have long practised at DALI, prioritises total system response and subjective musical performance over adherence to specific filter response profiles. An example of the benefits of the target function approach is illustrated by the differential filtering of each pair of bass drivers in the EPIKORE 11; the upper pair of bass drivers is low-pass filtered at a slightly lower frequency than the lower pair. This has the effect of tilting the low frequency dispersion lobe of the EPIKORE 11 slightly upwards, which benefits the way in which it integrates with typical listening room acoustics.

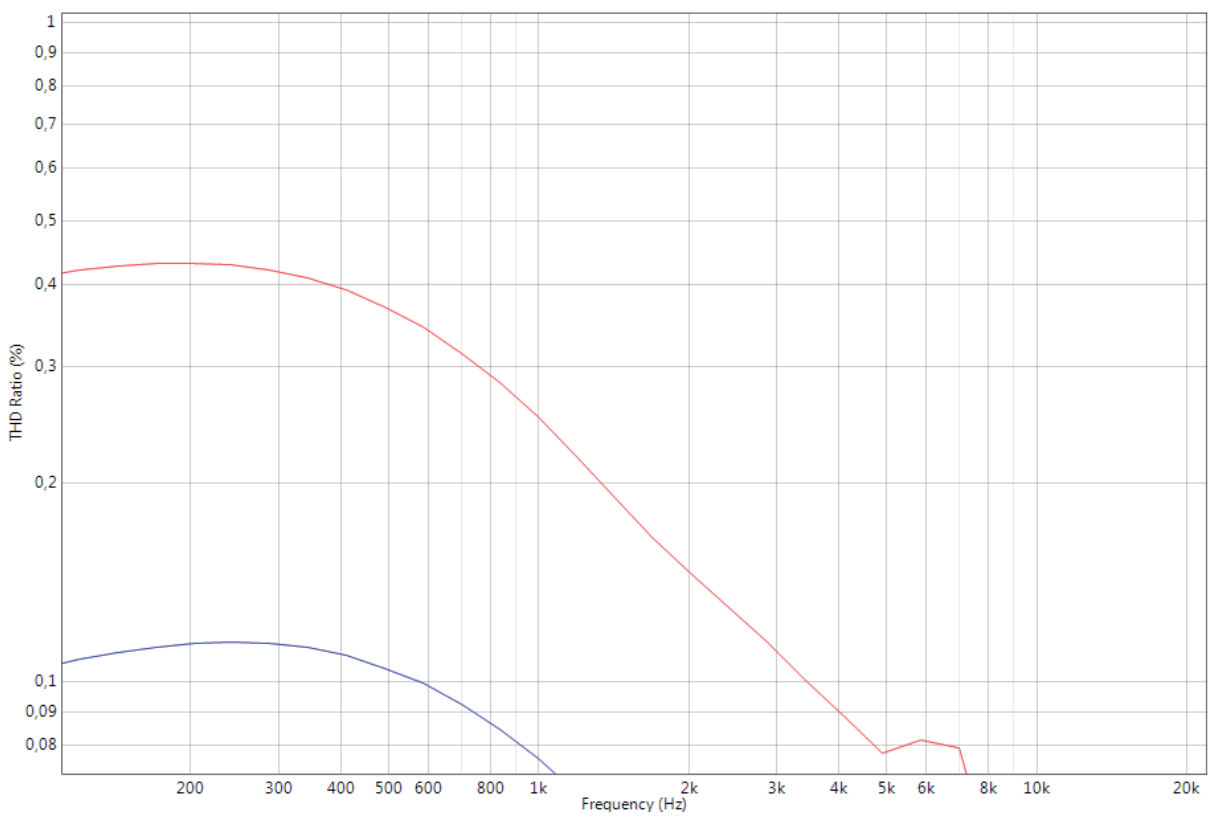


SMC KORE Inductors

Crossovers are not, however, simply about filter design and driver integration. Their idiosyncrasies and complexities also make component choice vitally important. Each EPIKORE 11 crossover component is selected based on subjective audio quality, rather than cost or physical size. In the majority of cases, the components that display the lowest loss or distortion offer the best subjective performance. The EPIKORE 11 crossover inductors that are of too high an inductance value for air-cored construction are an example of this philosophy. In these cases, we once again turned to SMC KORE inductors built on SMC Gen-2 cores for their magnetic yet non-conducting core material. Compared to standard air-core inductors (especially at high inductances), this technology enables lower DC resistance, shorter signal path and less vulnerability to crosstalk, and will reduce the current distortion in the crossover significantly compared to standard iron core inductors.

The EPIKORE 11 passive crossover module is located in the base of the enclosure. The crossover outputs are connected to the drivers and input terminals using high quality oxygen free stranded copper internal wiring. The input terminals themselves are newly developed and DALI designed items manufactured in very low resistance gold-plated brass, with extremely low contact resistance for the very best connection. The terminals can accept bare wire, spades or banana plugs. Four terminals are fitted to enable the EPIKORE 11 to be driven in either a bi-wire or bi-amp mode.

Current THD Ratio, crossover inductors



The measurement illustrates an inductor (— Blue) compared to an inductor with a conventional iron powder core (— Red). Both inductors are of 5.7 milli-Henry inductance, and in the measurement setup they are connected in series with a 4 Ohm resistor to create an appropriate load for the driving amplifier. The measurement shows that the SMC KORE inductor reduces pass-band Total Harmonic Distortion (THD) by a factor of around 3.5 vs. a conventional iron powder core.

DALI EPIKORE 11

Enclosure Design and Engineering

The DALI KORE introduced a new industrial design philosophy for DALI. A philosophy where aesthetic beauty, design integrity, engineering purity and manufacturing quality each commands equal weight. An holistic philosophy that created, in the DALI KORE, a truly striking result – in every respect. The design and development of the EPIKORE 11 was informed by the same philosophy, resulting in a similarly exceptional result. From its curved enclosure panels to its die-cast midrange driver and Hybrid Tweeter module, and to the smallest engineering detail, the EPIKORE 11 speaks of the same design philosophy as the DALI KORE.

The EPIKORE 11 enclosure is divided into separate compartments for the twin bass driver pairs and the midrange driver. Each bass driver pair sits in its own bass reflex loaded enclosures of 64 litres, tuned to a reflex frequency of 24 Hz.

The midrange driver however sits in a separate, damped 6 Litre closed enclosure. The EPIKORE 11 enclosure separation is engineered both to ensure that pressure changes in the bass driver enclosures do not affect the midrange, but also to optimise the internal volume for the midrange driver and ensure that internal sound reflections and standing waves are minimised so as not to disrupt the midrange performance.

The EPIKORE 11 enclosure comprises a thick curved and veneered MDF rear shell attached to gently profiled 40 mm thick MDF front panels for each bass driver section, and the aluminium die-cast element

that houses the midrange driver and EVO-K Hybrid Tweeter. The top and underside enclosure panels are created from profiled MDF in the latter case integrated with a die-cast aluminium sub-chassis with outriggers that carry adjustable spikes.

The front baffle, sides and top are heated in a process that allows us to press them into a rounded organic shape.

A rounded or bent structure is stiffer and more ridgid than a flat, square structure and will also help break up the tendency for internal standing waves inside the cabinet.

Designing an enclosure using a curved structure increases overall rigidity and significantly reduces cabinet resonances. Also, standing waves and cabinet resonances are practically eliminated, as there are no parallel surfaces on the inside or outside of the cabinet.

Within the EPIKORE 11 enclosure is a complex arrangement of brace panels, each one located strategically to minimise panel vibration. Between each brace panel, any residual cabinet vibration is dissipated using strategically placed bitumen surface damping panels. As a result, the EPIKORE 11 enclosure assembly is both immensely rigid and almost completely inert. It provides the perfect foundation on which the EPIKORE 11 bass, midrange and Hybrid Tweeter drivers can perform optimally and deliver outstanding sound performance.

DALI EPIKORE 11

Conclusion

Engineering an audiophile loudspeaker is always a story of give and take: adding enclosure curves while not taking too much internal volume, adding rigidity while endeavouring to suppress resonance. At DALI we've become practised at the story of give and take, and more importantly making the right choices to find the perfect balance between the many aspects of a loudspeaker's design. With the EPIKORE 11 we have designed a perfectly balanced loudspeaker system that expresses far more than the sum of its parts.

While the introduction of the EPIKORE 11 marks and celebrates DALI's four decades of audio innovation and achievement, of more significance is the 40 years of audio knowledge and wisdom it embodies. Each manufacturing component of the EPIKORE 11, and every element of audio expertise it expresses, can trace its roots back through the DALI story. The EPIKORE 11 is simultaneously an embodiment of our loudspeaker engineering heritage, and an expression of our unquenchable instinct to innovate and improve in the service of music in the home.

The EPIKORE 11 is not simply the last DALI loudspeaker of the the first four decades, it's the first DALI loudspeaker of the next four decades.

DALI EPIKORE 11 Specifications

Frequency range	29 – 34,000 Hz ±3 dB
Sensitivity	89 dB @ 1 m for 2.83 V
Nominal impedance	4 ohm
Maximum SPL	116 dB
Crossover frequency	170 / 370 / 3,100 / 12,500 Hz
Crossover principle	4½-way
Recommended amplifier power	40 – 1,000 Watt
High frequency driver(s)	10 × 55 mm ribbon 1 x 35 mm soft dome
High frequency diaphragm	Planar magnetostatic ribbon Soft woven fabric
Low/Mid frequency driver(s)	4 x 8 inch 1 x 6½ inch
Low/Mid frequency diaphragm	Wood fibre cone
Connection input(s)	Bi-wire
Enclosure type	Bass reflex
Bass reflex tuning frequency	24 Hz
Recommended placement	Floor
Recommended distance from rear wall	35 – 120 cm
Dimensions (H x W x D)	1,602 x 422 x 554 mm 63 x 16.6 x 21.8 inches
Weight incl. grille	75.6 kg 166.6 lb
Shipping weight	176 kg (pair) 388 lb (pair)
Finishes	High Gloss Black High Gloss Walnut High Gloss Maroon
Accessories	Manual Inlay card Cleaning cloth Spike outriggers (two pairs) Magnetic spike feet Terminal jumpers Floor protection pads 5 mm Allen key Magnetic front grille
Spike thread size	M12-1

The information provided in this manual is subject to change without notice.

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