KEF

KEF R&D

Q Series with MAT™ (2024)

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KEF
Uni-Q Driver Array
Metamaterial Absorption Technology

Introduction

Now in its ninth iteration since 1991, the Q series continues to benefit from advanced technologies developed for KEF's flagship BLADE and REFERENCE models.

This latest generation, featuring MAT, includes a complete system overhaul and the introduction of two new models, to set a new standard once again for 'entry-level' sound quality for all domestic HiFi applications, from music to home cinema.

Philosophy

"Of all art, music is the most indefinable and the most expressive, the most insubstantial and the most immediate, the most transitory and the most imperishable. Transformed to a dance of electrons along a wire, its ghost lives on. When KEF returns music to its rightful habituation, your ears and mind, they aim to do so in the most natural way they can... without drama, without exaggeration, without artifice."

Raymond Cooke OBE, KEF Founder

The principles of what makes a good loudspeaker system remain the same regardless of the product range in question.

At KEF, the design priorities continue to be:

1. Smooth on and off-axis performance – ensuring a balanced response in all directions.
2. Low distortion – allowing the drivers and the drivers alone to accurately reproduce the intended signal without any artefacts.
3. Controlled, linear driver operation – optimising the driver performance both in and out-of-band to maintain control and accuracy.
4. Low colouration – designing crossover networks to achieve a result that is perceptually as neutral as possible and free of any artefacts throughout the audible spectrum.

Since its inception in 1961, KEF's R&D engineers have been committed to delivering high-performing HiFi products that excel in all areas of technical competence; by consistently refining their design approach using the latest tools, technologies, and expertise developed over decades.

While objective science forms the foundation of a high-quality loudspeaker system, the ultimate testament to the success of KEF's designs and ideas lies in listening experiences they deliver.

This approach continues to guide the balance of engineering compromises that are inevitable in the design of high-quality loudspeaker systems.

3-Way Design

A loudspeaker system is the sum of its parts. To meaningfully upgrade the overall performance of the new Q series, the focus was on maximising the performance of each frequency section individually. This approach led to the decision to move from a 2.5-way to a full 3-way design, prompting a detailed redesign of the acoustic packages from the ground up. In addition to the updated system topologies, the new products build on advanced technologies developed by KEF since the launch of the previous Q series in 2017.

The following key improvements and technologies are featured in varying combinations throughout the new range of models:

- 12th Generation Uni-Q™ with MAT™
- Flexible Decoupling Chassis to minimise vibration transmission from the Uni-Q to the front baffle and adjoining cabinet walls.
- Shadow Flare around the Uni-Q to minimise baffle edge diffraction.
- FEA-optimised LF driver moving assembly for greater linear travel and lower distortion.
- Optimised cabinet loading using multiple true LF drivers.
- Rear-firing bass-reflex optimally positioned to minimise coupling with internal cabinet resonances.
- Updated crossover topologies and components, to improve the summed on and-off-axis response and consistency.

The new acoustic packages across the range form a robust foundation for developing a diverse range of products, designed to meet the goal of delivering high-performance loudspeakers at an affordable price.
The result is a collection of eight models. They include two floor-standing speakers (Q7 Meta, Q11 Meta), three bookshelf speakers (Q1 Meta, Q3 Meta, Q Concerto Meta), one on-wall speaker (Q4 Meta), one ATMOS speaker (Q8 Meta), and one centre channel speaker (Q6 Meta).

The latest additions to the range—the Q Concerto Meta, a 3-way bass-reflex bookshelf speaker, and the Q4 Meta, a 2-way bass-reflex on-wall speaker—aim to broaden application scenarios, catering to an even wider array of domestic HiFi applications.

Driver Technology

12th Generation Uni-Q™ with MAT™

The Uni-Q driver array has been the cornerstone of KEF's driver technology since its debut in 1988. The approach of packaging the midrange driver and the tweeter into one co-incident driver array offers a distinct acoustic advantage of closely aligning their acoustic centres to the same point in space. This facilitates ideal point source behaviour across their combined operational bandwidth, which in effect encompasses most of the audible frequency range.

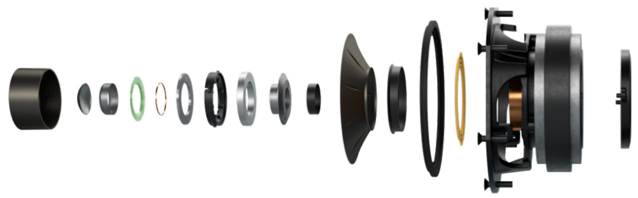

Figure 1. Exploded view of a 12th Generation Uni-Q designed for Q Series with MAT

The merits of the Uni-Q design extend beyond time alignment alone. The geometrical profile of the midrange cone is designed to function as a waveguide for the dome tweeter, thus aligning the directivity patterns of the two drivers. The point source behaviour combined with the matched directivity between the two drivers helps maximise the temporal and spatial coherence of the sound energy radiated into the listening environments. This allows the Uni-Q array to distribute sound energy very evenly over a broad range of angles, free of interference and cancellation artefacts that typically influence other designs where two different drivers in two distinct positions on the front baffles operate over the same range of frequencies in the crossover region.

Figure 2 compares two speaker arrangements: the point-source arrangement of the Uni-Q driver array and a standard driver arrangement with separate tweeter and midrange units spaced 100mm apart. To emphasise the effect of the separation alone, all drivers are modelled as perfect monopole sources with omnidirectional directivity patterns. Despite reasonably flat on-axis responses for both arrangements, the Uni-Q arrangement exhibits significantly better off-axis stability in the vertical plane (plane of separation) around the crossover region at 1kHz, as indicated by the consistencies of the colour patterns in the normalised directivity contours.

The uniform off-axis performance also extends in the horizontal plane. As a result, with the Uni-Q arrangement, listeners are no longer tied to a single "sweet spot" between the speakers, allowing them to sit anywhere and still enjoy the intended balance of the two drivers over a much wider listening window. Further details on the concept and merits of the Uni-Q technology are available in the REFERENCE 2014 white paper [1].

Three new 12th generation Uni-Qs have been developed for the following products:

- 5.25" Uni-Q for Q1 Meta, Q4 Meta, and Q8 Meta.
- 6.5" Uni-Q for Q3 Meta.
- 4" Uni-Q for Q Concerto Meta, Q6 Meta, Q7 Meta, and Q11 Meta.

Compared to the 11th generation Uni-Q of the outgoing Q series, the new Q Meta Uni-Qs come with a range of improvements including the Tweeter Gap Damper, an updated midrange Cone Neck Decoupler as well as structural improvements to the Tangerine Waveguide. Details of improvements to the 12th generation Uni-Q are summarised in the R Series with MAT white paper. [2]

New Single Layer MAT™

LS50 Meta and LS50 Wireless II saw the first introduction of the Metamaterial Absorption Technology (MAT) to the 12th generation Uni-Q in 2020 [3]. Since then, MAT has been incorporated in BLADE, REFERENCE and, most recently, the R Series with MAT.
MAT refers to an engineered metamaterial absorber disc that is designed to achieve an exceedingly high amount of absorption in a limited amount of space. The MAT disc is acoustically coupled to the back of the tweeter dome, where its function is to completely absorb the rearward sound waves radiated by the tweeter dome back into its cavity. This absorption is crucial for minimising

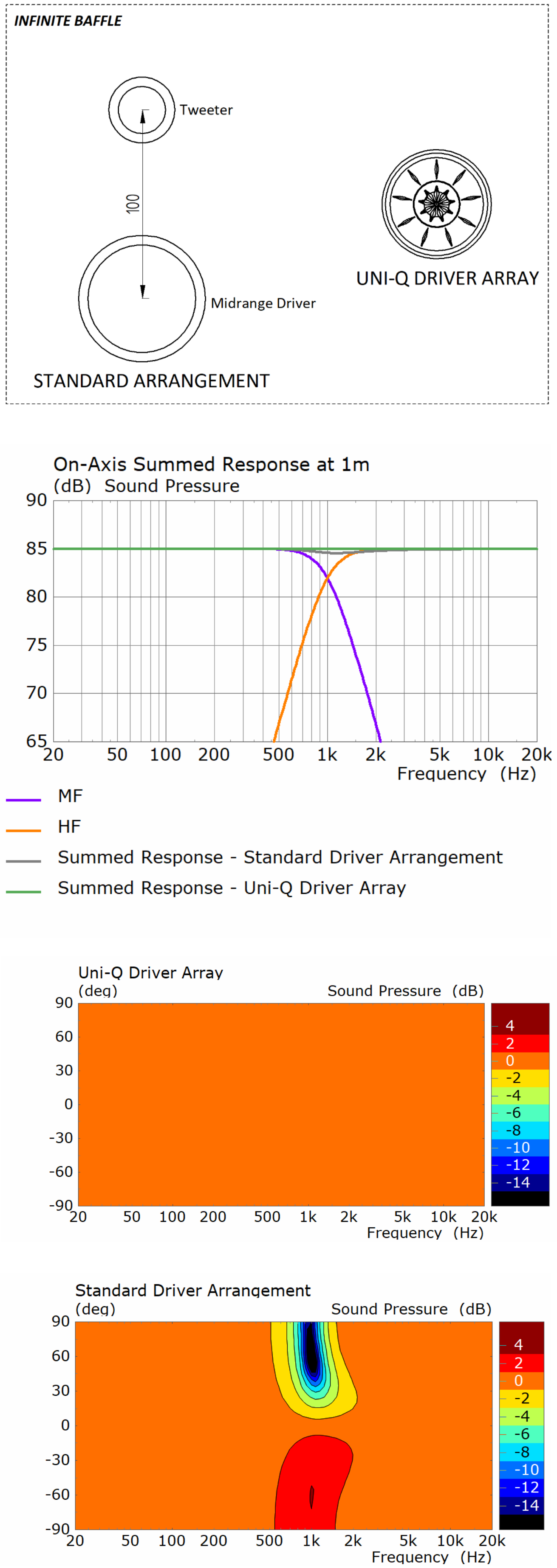

Figure 2. Schematic driver arrangements on an infinite baffle (top), summed on-axis response at 1m on tweeter axis (middle), normalised vertical directivity contour for both driver arrangements (bottom)

distortion and other artifacts, that may result from the unattenuated rear sound energy reflecting on the tweeter dome.

MAT employs a network of individually tuned quarter-wavelength absorbers, which are folded into tubes and arranged within a disc. Each tube is designed to provide very high absorption over a narrow range of frequencies [4]. When multiple discrete tubes operate in concert, the MAT absorber achieves near-perfect absorption coverage across the entire operational bandwidth of the tweeter. This level of absorption far surpasses that achievable with conventional approaches and other natural or synthetic materials, including the polyurethane (PU) foam bungs used in the 11th generation Uni-Q of the previous Q series. Figure 3 shows a comparison of the two solutions and their resulting absorption performance, quantified by the absorption coefficient.

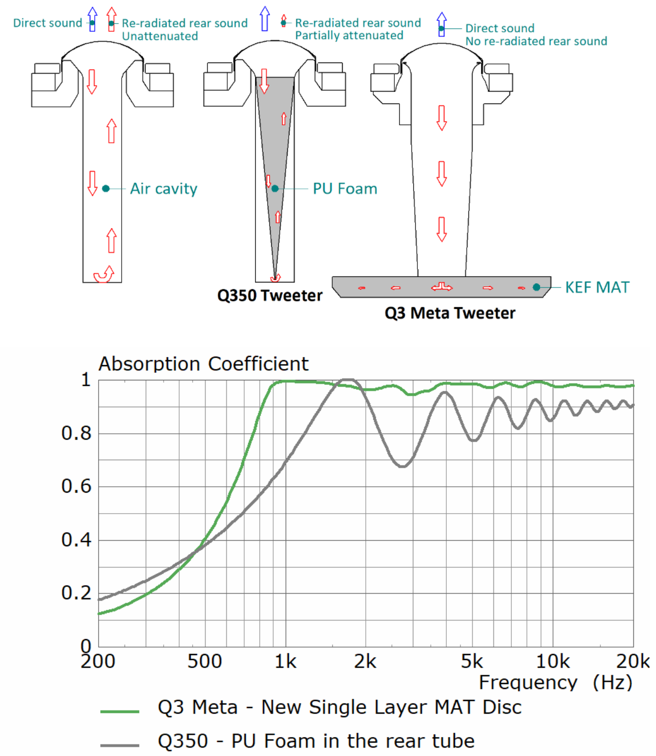

Figure 3. Schematic representation of the tweeter rear cavity in three configurations (top). Simulated absorption coefficients at the back of the tweeter dome (bottom).

The new MAT discs feature a single-layer construction with a channel count of 15 and 20 channels for the 2- and 3-way Uni-Q configurations, respectively. They follow a simplified packaging approach evolved from the 2-layer MAT discs featured on previous products. To maximise the effectiveness of these streamlined designs, critical parameters such as the aperture size,

radial lengths and cross-sectional area of the tubes as well as their tuning frequencies have been re-optimised using advanced, in-house Finite Element Analysis design and optimisation tools. Figure 4 shows the internal MAT channel structure consisting of 20 channels.

Figure 4. Single layer MAT disc with twenty distinct quarter-wave absorber channels developed for the 3-way Q Series with MAT Uni-Q

Midrange Driver

Excursion Optimisation

The mid-frequency range is crucial in audio reproduction as it encompasses the fundamental frequencies of human speech and many musical instruments. Additionally, human hearing is most sensitive in this range, particularly between 2kHz to 4kHz, making this frequency range vital for vocal clarity and overall perception of spatial and temporal cues embedded in the stereo signals. As a result, minimising distortion in the mid-range is the key to enhancing the clarity and realism of the projected soundstage.

In a 2.5-way design, the midrange driver is responsible for supporting the bass section in achieving the system's low-frequency sensitivity and extension targets down to 20Hz. This comes at a cost of large excursion for the midrange driver, requiring the use of a large radiating area and a motor system with sufficient mechanical clearance to support the large peak-to-peak travel distances.

As a result of the 3-way design approach for the new systems, the midrange section has been redesigned to operate within a targeted frequency range of 400-2.5kHz. Increasing the passband threshold to 400Hz, comes with a significant reduction in the excursion demand for the midrange drivers. This is shown in Figure 5. This reduction in excursion results in further reduction in excursion, inductance and inductance modulation related distortion that dominates a system's midrange distortion performance.

Flexible Decoupling Chassis

As the voice coil oscillates in the magnetic gap, the motor system experiences an equal and opposite reaction force. The level of this reaction force is exactly equal to the forward force acting on the voice coil which increases with playback level. In a normal configuration, where the motor and chassis are bolted together, this reaction force leaks to the front baffle and adjoining cabinet walls causing them to vibrate and reradiate sound that may interfere with and colour the direct sound from the drivers.

Although the amplitude of this parasitic cabinet vibration may be minor compared to that of the drivers themselves, the contrast in their radiating areas (front baffle being over 2000x larger by area than the midrange cones) can still generate a significant amount of undesirable colouration.

The Flexible Decoupling Chassis (Figure 6), as featured in BLADE, THE REFERENCE and R Series with MAT, provide a lossy mechanical link between the motor systems and the cabinet walls. The spring elements in parallel with the damping pads, decouple and dissipate the vibrations from the motor system, preventing them from leaking to the front baffles. This results in a significant reduction in the baffle vibrations, significantly improving the overall clarity of the system.

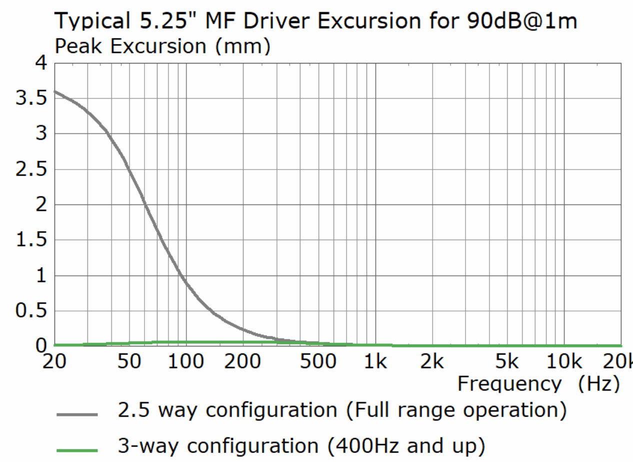

Figure 5. Typical excursion requirements for a 5.25" MF driver in a 2-way and 3-way configuration. Passband level of 90dB at 1m

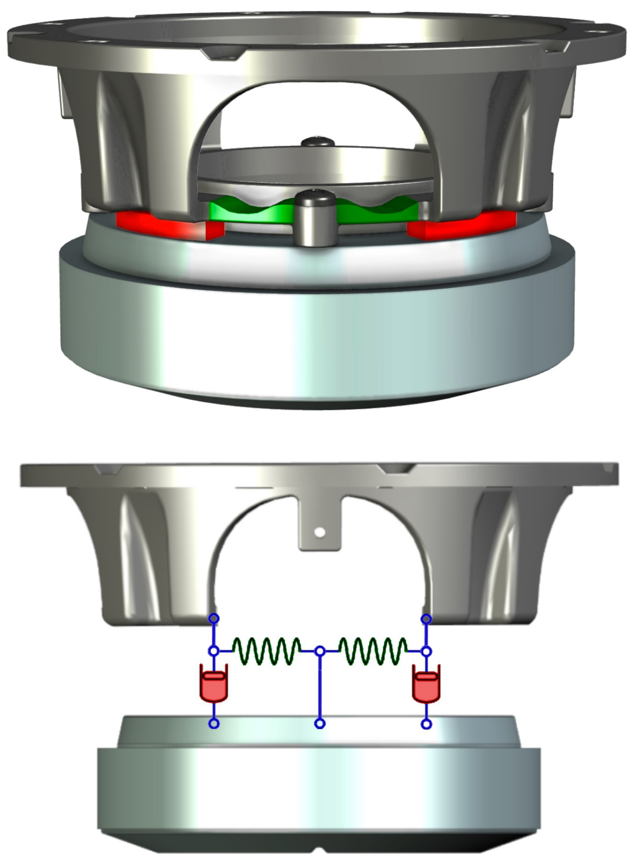

Figure 6. Flexible decoupling chassis with spring elements (green) and damping pads (red). R Series with MAT Uni-Q

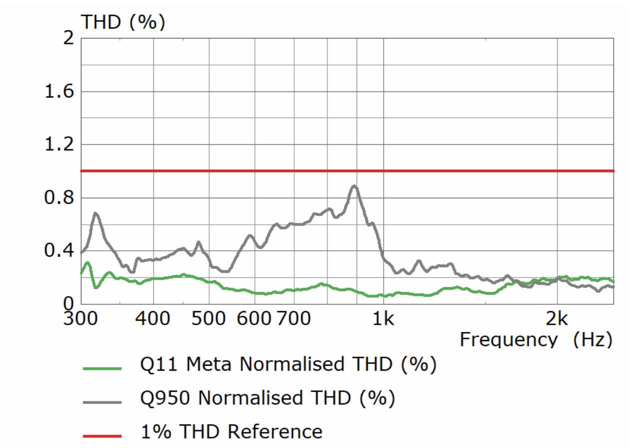

Figure 7. Q950 (grey) and Q11 Meta (green) midrange in-situ THD ratio (%) in response to 90dB SPL (fundamental). Also shown is the 1% THD threshold (red)

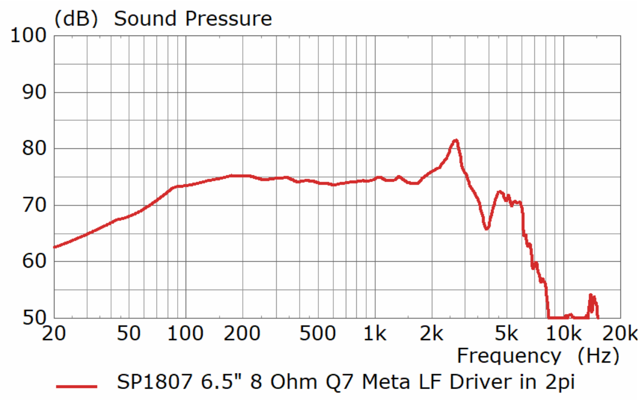

Figure 8. 6.5" 8 Ohm LF (Q7 Meta) 2pi infinite baffle response (2.83Vrms at 1m)

Radiating Area Optimisation

The 3-way systems in the new Q series use a 4" Uni-Q across all models. This small diameter Uni-Q includes a midrange driver with a smaller radiating area than the ones used on the previous Q series. This change in approach in the system topology has been afforded through the optimisation of individual driver sensitivities, their excursion limits and crossover points to maintain the overall system sensitivity and maximum output, whilst enabling the following benefits:

- Stiffer cone geometry which helps push the diaphragm break-up further out of the operating band of the driver.
- Wider and more uniform midrange directivity.
- Reduction in the midrange driver rear cavity volume allows for a larger LF enclosure to improve bass extension and efficiency.

The largest MF driver size difference is on the Q11 Meta, superseding the outgoing Q950, with a 4" MF cone replacing the 8". Figure 7 compares their on-axis normalised THD performances in response to 90dB SPL at 1m.

Low Frequency Drivers

The new LF drivers follow the same two-part hybrid construction as the previous generation, incorporating an aluminium dust cap on top of a paper cone to form a rigid, lightweight assembly. To achieve higher system dynamics and headroom, the LF driver counts have been upgraded across all 3-way models. The Q11 Meta, and the Q7 and Q6 Meta use 3 and 2 6.5" LF drivers, respectively.

Compared to the previous generation, the new LF drivers feature the following improvements:

1. Redesigned motor system with higher efficiency and maximum voice coil displacement.
2. New soft parts design with a deeper profile to improve diaphragm break-up performance.

The angle of the paper cone, its size, and the radius of the aluminium dust cap have been redesigned to improve their structural rigidity whilst minimising their moving mass. Figure 8 shows the 2pi response of the new LF driver (8 Ohm version). The drivers have been designed to have smooth response both in and considerably out of band. This can be seen in Figure 8, where the first diaphragm break-up peak is seen at 2.6kHz, which is more than two octaves above the intended crossover frequency range of 450-500Hz for this driver. The same bass drivers have been used throughout, saving for the difference in their voice coil resistances, allowing all 3-way models to benefit from the latest improvements.

Figure 9 shows a comparison of the THD performances of the new and previous flagship systems, Q11 Meta and Q950 in response to 90dB SPL at 1m on-axis, respectively. The significant distortion reduction achieved with the new system, along with the improved efficiency and headroom from the increased LF driver count, translates to a deeper, cleaner and more accurate response.

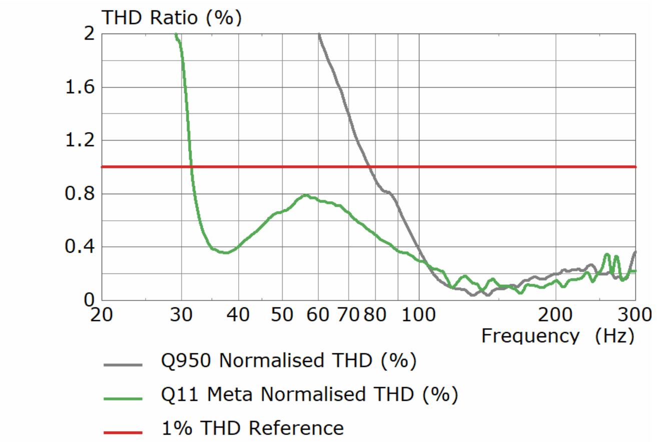

Figure 9. Q950 (grey) and Q11 Meta (green) low-frequency in-situ THD ratio (%) in response to 90dB SPL (fundamental). Also shown is the 1% THD threshold (red)

Cabinet Design

The visual design of the new cabinets retains the familiar rectilinear shape with the same range of finishes: satin white, satin black, and walnut.

In terms of form factor, the new floorstanders feature slimmer front baffles that, in addition to the reduced visual footprint, also allow for a wider horizontal directivity that is necessary to create a stable soundstage across a wider range of listening angles. This is also one of the reasons why multiple smaller LF drivers have been used in place of one large LF driver on the Q11 Meta.

Figure 10. Q11 Meta in walnut

Uni-Q Shadow Flare

As the sound generated by the tweeter reaches the edges of the rectilinear cabinets, it is re-radiated and scattered into the room. This secondary radiation is delayed compared to the direct sound, by the amount of time it takes sound to reach the edges, resulting in a degree of time smearing that impairs the clarity of what the listener hears. In the frequency domain, this phenomenon manifests itself as response undulations due to the varying degree of summation and cancellation interactions between the direct and secondary sources, impairing the timbre of the intended music signal.

The Uni-Q Shadow Flare is an extension of the midrange cone's geometrical profile that smoothly directs the radiation from the tweeter away from the cabinet edges. The redirection of the direct sound leaves the edges in the acoustic "shadow" of tweeter's forward radiation. As illustrated in Figure 11 [5], the Shadow Flare drastically reduces the occurrence and, therefore, the audible impact of edge diffraction resulting in enhanced clarity and smoothness in the sound reaching the listener.

This technology was first developed for the 2014 REFERENCE systems, and subsequently incorporated in

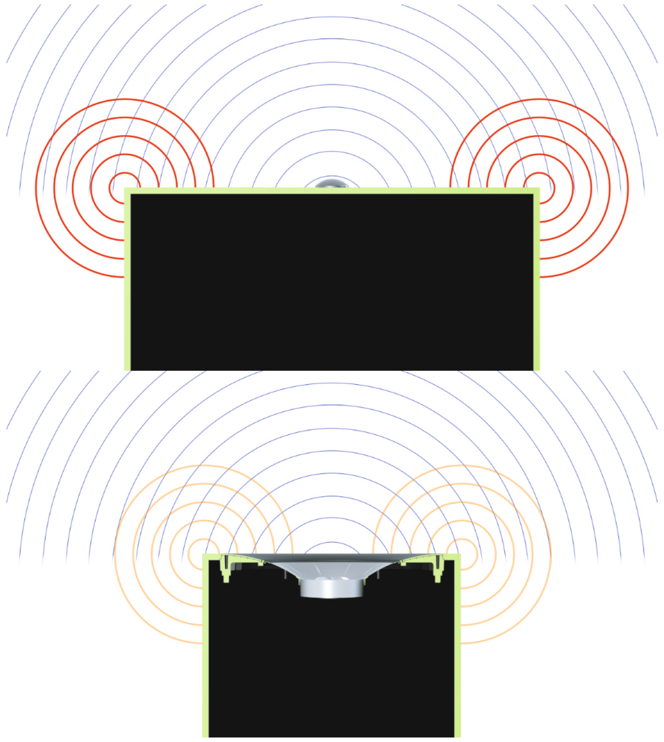

Figure 11. Diagrammatic representation of the tweeter in a flat baffle (top) and in the Uni-Q arrangement with a Shadow Flare (bottom). Direct sound is in blue, and secondary, diffracted sound (red and orange)

Figure 12. Uni-Q with Shadow Flare as seen on Q11 Meta

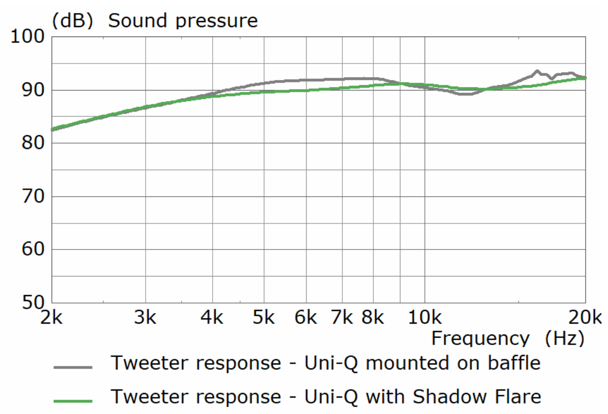

Figure 13. Tweeter response with (green) and without (grey) the Uni-Q Shadow Flare

the 2018 and 2022 R Series systems. This is the first generation of the Q series to feature the use of the Shadow Flare.

Figure 13 shows the effect of the Shadow Flare on the response of the tweeter.

Low Frequency Enclosure

Enclosure volume is one of the three key factors determining the low-frequency performance of a passive loudspeaker system, the other two being extension and sensitivity [6][7]. For a high-sensitivity, low extension passive system, the LF enclosure volume must be large.

Optimised Cabinet Loading

Large enclosures are susceptible to standing wave modes within the LF passband, where internal reflections at specific frequencies combine constructively to give rise to a build-up of energy. This stored energy decays at audibly different rates than nearby frequencies, resulting in certain notes ringing beyond their intended durations or being significantly louder than other notes. Depending on the position of the LF driver in the cabinet, multiple standing wave modes can be excited simultaneously, which colour the sound either by influencing the motion of the driver's diaphragm, output of the ports or excessive vibrations leaking into the acoustic environment via the cabinet walls.

One mitigation measure is to push the problem mode frequencies out of the passband of the radiating drivers. This can be achieved by breaking down the cabinet into multiple smaller sections, and thus reducing the wavelength of the standing wave pattens and increasing their frequencies. However, the added complexity and expense of such a modular construction can be prohibitive for an entry-level system.

Consequently, the most effective solution relies on avoiding the excitation of the standing wave modes in the first place.

Standing wave modes

The lowest order and therefore the most problematic modes occur along the longest singular dimension of the cabinet, usually the height dimension of a floorstander. The pressure distribution of a standing wave mode generates stationary patterns of high- and low-pressure regions, as shown in Figure 14. The same is also true for velocity.

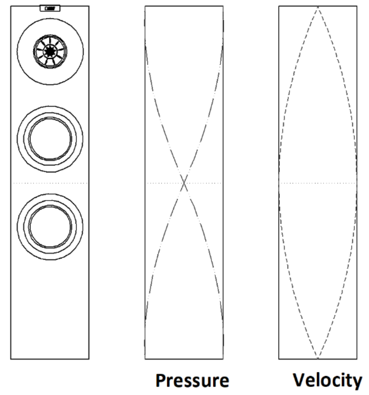

Figure 14. Standing wave pressure (middle) and velocity (right) mode shapes using Q7 Meta as example

The extent to which a driver excites a particular mode can greatly be reduced by placing the driver at the zero-pressure position (the pressure node) of that mode. This is known as mode suppression. For multiple LF driver systems, a similar result can be achieved by placing two drivers symmetrically around the nodal point such that the excitation from one can be completely cancelled by the other. This is known as mode cancellation. This is shown in Figure 15a.

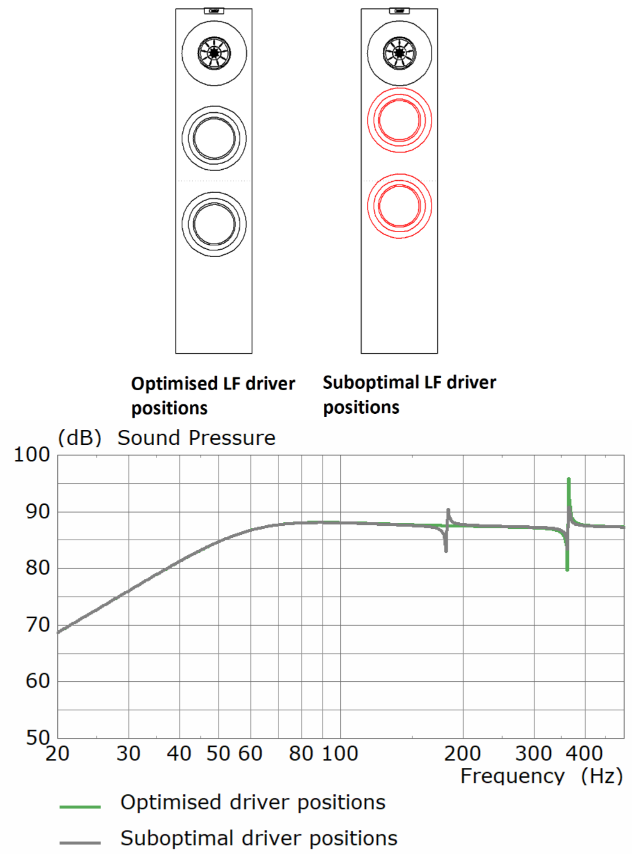

Figure 15a. Standing wave mode manipulation driver positions in the noted combinations

This concept of optimal positioning also extends to the absorption material packed inside the enclosures. Due to their porous nature, they are most effective in regions of maximum particle velocity (and low pressure). This is shown in Figure 15b.

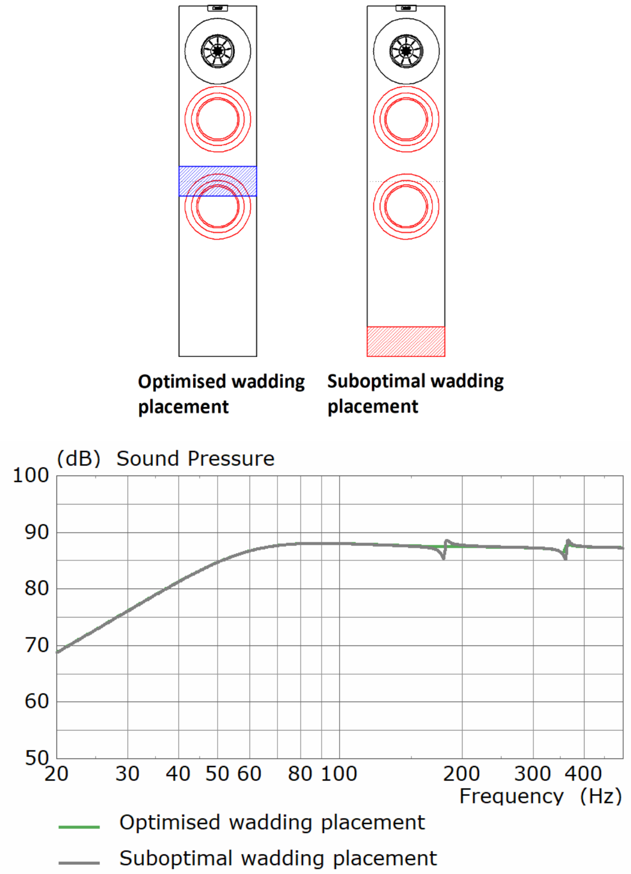

Figure 15b. Standing wave mode manipulation wadding placement in the noted combinations

The new Q floorstanders employ a combination of the three approaches; mode cancellation, mode suppression and optimised attenuation; to minimise the occurrence and audibility of standing wave modes inside the cabinet. This is shown in Figure 16.

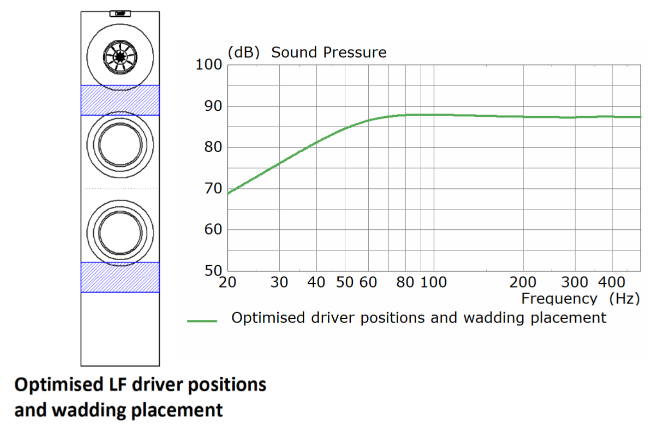

Figure 16. Combined result of optimal driver and wadding placements used for Q7 Meta

Thus, the increased LF driver count for the Q6, Q7 and Q11 Meta, not only support their LF performance targets but also enable meaningful improvements in their cabinet loading conditions to improve the overall bass response of the systems.

Bass Reflex Ports

For a passive system, reflex loading, via a port or ABR, is extremely useful as it helps boost LF efficiency for a given driver size and box volume. This augmentation of the bass output comes at a further advantage of reduced driver movement over the operating range of the reflex mechanism, resulting in lower driver and system distortion.

The previous Q series used Auxiliary Bass Radiators (ABRs) as the mechanism of reflex loading. ABRs form a resonant system where, upon excitation, the mass of the moving assembly oscillates against the spring compliance of the enclosed volume of air. The resonance frequency of this coupled system is tuned to achieve the target low frequency alignment of the system.

A port works in an equivalent way, where the mass is provided by the volume of air trapped inside the port tube and the flares at either ends. Despite their similar operation, ports offer two key advantages in the form of optimal placement of port ends both inside and outside the enclosures as well as adjustment of their output via the use of port bungs.

Much like the concept of optimal driver placements, ABRs and ports are also susceptible to coupling with the internal enclosure standing wave modes. While the placement of ABRs on the front baffles may be restricted by visual design considerations, the rear-firing ports on the new Q series systems take advantage of optimal positioning to minimise coupling with internal standing waves over the entire LF passband. This follows the cabinet design approach successfully demonstrated in THE REFERENCE and R Series floorstanders. Furthermore, the supplied port bungs enable users to partially or completely block the ports' output to suit their setup requirements and preferences. The adjustable tunings are shown in Figure 17.

Optimising Port Flow Velocity

One potential limitation of ports is their susceptibility to turbulence at high playback levels. Turbulence arises as the air trapped inside the port exits into open air or the cabinet's interior via rapid expansion under high velocity.

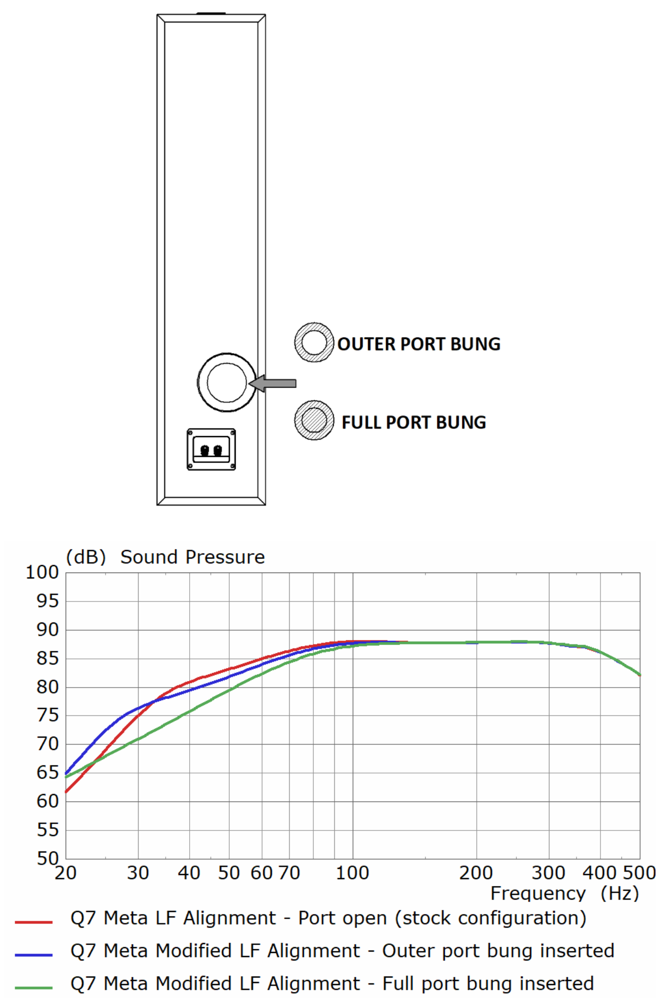

Figure 17. Adjustable port tunings for the Q7 Meta using the supplied two-part bung

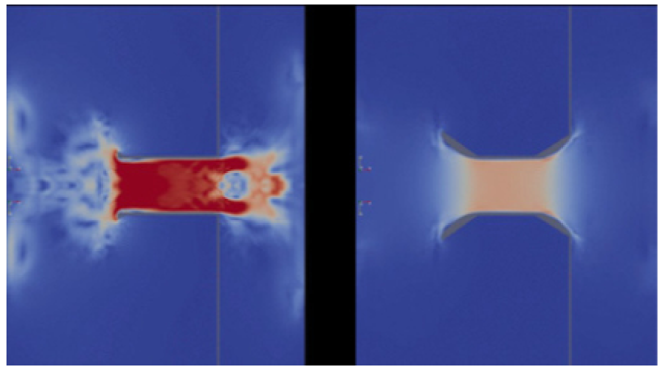

Figure 18. Computational Fluid Dynamics (CFD) model showing the effects of a straight tube (left) and one with optimised flared profiles at either end (right) on the turbulence behaviour,

Detrimental artefacts such as distortion, dynamic range compression and chuffing noises all increase drastically following the onset of turbulence.

The new Q series addresses this limitation by focusing on two key areas: minimising flow velocity by using a large 64mm port and incorporating an optimally flared profile at both ends, to enable gradual airflow expansion at the exits.

Together, these measures significantly reduce the likelihood of turbulence, even at elevated playback levels, ensuring cleaner and more accurate bass performance.

The perceptual benefit of these measures is a well-extended, well-controlled bass response, free of resonant artefacts.

Crossover Network

The primary function of the crossover network is intuitively simple, which is to split the incoming signal into band-limited sections appropriate for the individual driver sections' operation. However, in practice, the crossover network is one of the most consequential aspects of the system design that directly determines the sound output that a listener hears in a room.

The qualities of a well-designed crossover network are:

1. The core function, which is to split the signal into sections that each driver section can optimally handle without exceeding its operation limits, both in and reasonably out-of-band.
2. The first quality parameter, which is to ensure that the signal is split in such a way that the sum of the individual parts in the far-field is smooth not only on-axis but also off-axis.
3. Finally, the second quality parameter, the design of the crossover network must ensure that a neutral timbre is maintained whilst addressing the previous two points.

Following the findings from the development of BLADE, REFERENCE and R Series with MAT, priority was assigned to achieving a smooth acoustic power average and vertical and horizontal response averages for optimal in-room performance. The rationale for this lies in understanding the physical acoustic environment in which the speakers will be used.

Acoustic Environment Considerations

In a typical room, the sound reaching the listeners is a combination of the direct sound (travelling from the source loudspeaker straight to the listeners) and the reflected sound (reaching the listeners via many reflections from the room boundaries and other objects). In relative terms, sound energy radiated directly on-axis only accounts for a small portion of the total sound energy reaching the listeners. The rest is accounted by the off-axis energy radiated in all directions beyond the on-axis direction alone. A listener's ability to 'hear through' rooms and use the reflections to perceive three-dimensional phantom sound objects across the projected soundstage relies greatly on the similarities between the direct sound and its reflections [8].

Optimising the off-axis performance

One of the key technical benefits of the Uni-Q driver array is its matched directivity. As the listener moves off-axis, the tweeter response drops at approximately the same rate as the midrange driver, improving the uniformity of the tonal balance over a larger listening area as well as the stability of the virtual objects in sound stage.

The selection of the crossover points and the passband levels of the individual driver sections are thus driven by the goal of maintaining this smooth and consistent directivity across the entire audible frequency spectrum. Also contributing to the directivity characteristics of the loudspeakers are other factors such as edge diffraction, driver spacing at low frequencies, mounting conditions, and radiating dimensions of the individual drivers. The challenge is to strategically balance these factors to achieve a smooth and constant slope in the acoustic power response, along with smooth and balanced vertical and horizontal response averages. Figure 19 shows the realisation of these targets on the Q7 Meta.

The slight downward tilt in the on-axis response is attributable to the inverse relationship between the radiator size and its directivity, which is the frequency threshold above which its radiation pattern starts to narrow. As the tweeter (0.75") is much smaller and, therefore, less directional than the LF drivers (6.5"), maintaining the directivity and power response smoothness requires the tweeter's passband level to be shelved on-axis.

Figure 20 shows a comparison of the power response of the Q7 Meta against the R7 Meta, highlighting the consistency in the tuning targets for the two speaker ranges.

Topology and component selection

The new 3-way designs employ all second order electrical filters. These do not follow any particular type and are instead designed with careful consideration of the drivers' natural roll-offs, their summed behaviour as well as extensive listening tests.

By combining driver development with crossover design, the minimum impedance requirements are balanced between the crossover components and the voice coil resistances, eliminating the need for a conjugate network. This simplified approach reduces the number of components in the signal path, preserving signal

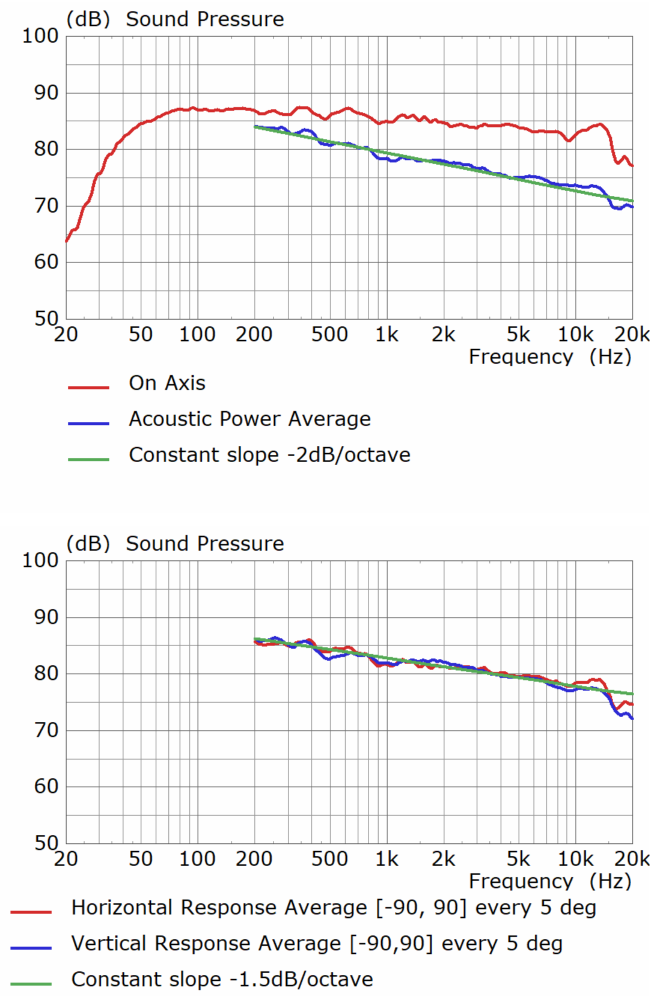

Figure 19. Q7 Meta on-axis response and acoustic power average (top), and horizontal and vertical response averages across the frontal hemisphere (bottom)

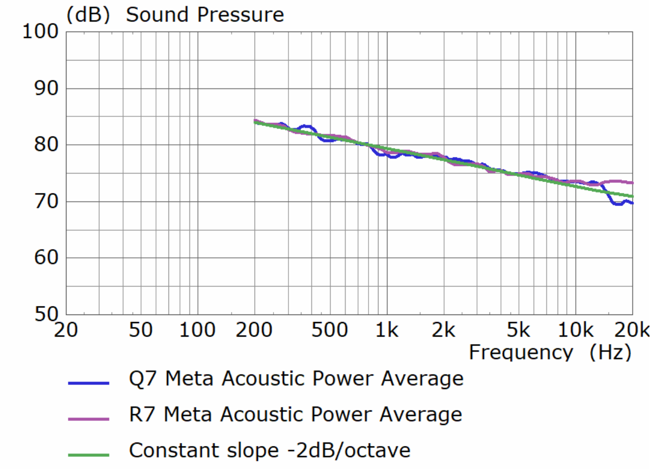

Figure 20. Q7 Meta and R7 Meta acoustic power averages

integrity while allowing for the use of higher-quality components without a significant cost penalty.

The improved choice of components features low-loss film capacitors and air-core inductors in the tweeter path and higher performance laminated inductors over powder-core inductors for the MF and the LF paths.

Measurement Methodology

To design high-quality crossovers, it is necessary to first capture high-quality anechoic measurements of the drivers in -situ. Figure 21 shows an illustration of KEF's anechoic chamber microphone array. This array features 13 microphones arranged on an equidistant arc.

The speaker to be measured is mounted at the focal point of the arc and a sequence is initiated that captures the response of the individual driver sections at the 13 vertical positions over a horizontal rotation of 180 degrees. For a 3-way system with three driver sections, this amounts to over 1400 individual measurements. The 'sphere' of measured data is then post-processed to generate a collection of acoustic metrics that inform the design of the crossover network. This process is iterative with extensive listening stages in between to track the evolution of objective improvements against subjective impressions.

In conclusion, the outcome of this crossover design strategy is a range of well-designed, well-engineered loudspeakers. They follow the footsteps of KEF's higher end HiFi products, in delivering a strong stereo image over a wide listening area, the realism of which is enhanced by the even tonal balance of the reflected energy in the listening room.

Summary

Nine iterations later, the Q series with MAT further strengthens the already impressive price-to-performance ratio of KEF's entry-level Hi-Fi range.
Using critical engineering, proprietary technologies, and sophisticated in-house measurement and simulation tools, the new generation of Q products deliver a significant upgrade in both performance and fidelity, making them ideal candidates for any 2-channel or multichannel system. Additionally, the consistent voicing approach affords users great flexibility in combining loudspeaker products from different ranges to create versatile multichannel systems that are best suited to their individual tastes, requirements, and budgets.

This white paper serves to share rationale behind the engineering decisions made in the development of the new Q Series, offering readers an insight into the product development practices at KEF R&D. For further details on additional features and innovations, readers are encouraged to explore the related KEF white papers.

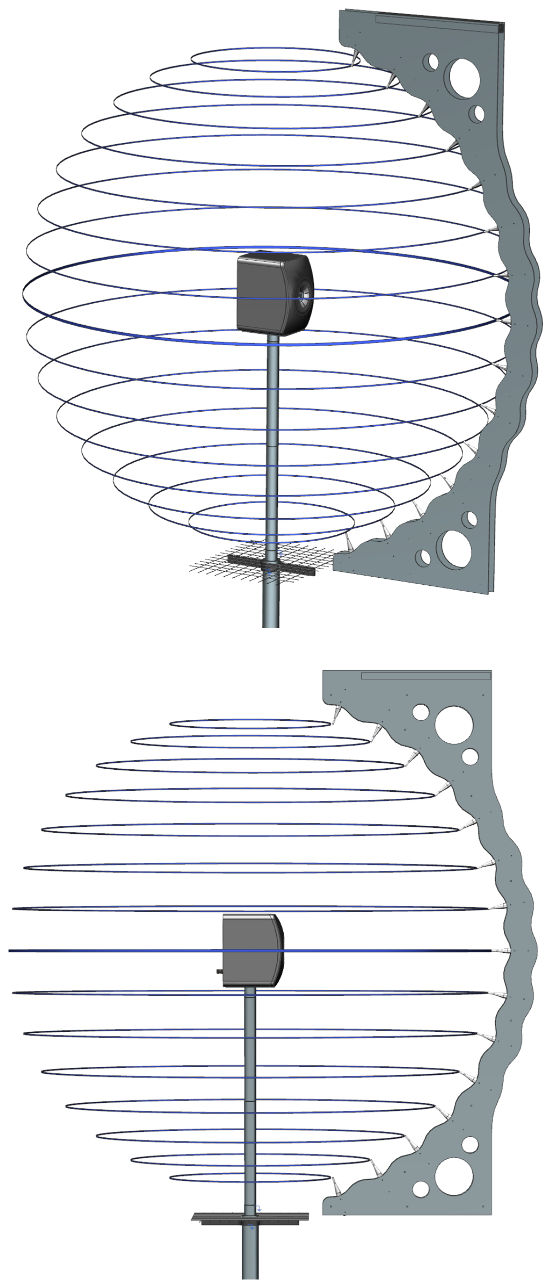

Figure 21. KEF's anechoic chamber microphone array used for the development of Q Series with MAT

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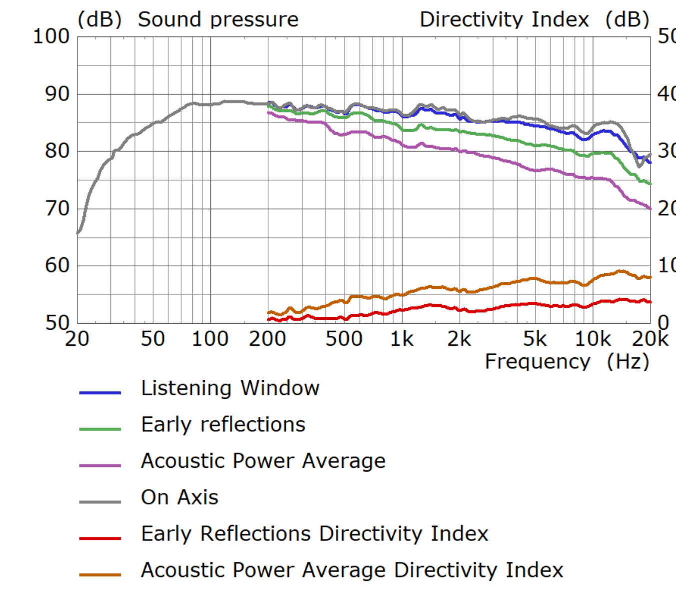
Q Series with MAT™

Model Information, Specifications and Measurements

Q11 Meta

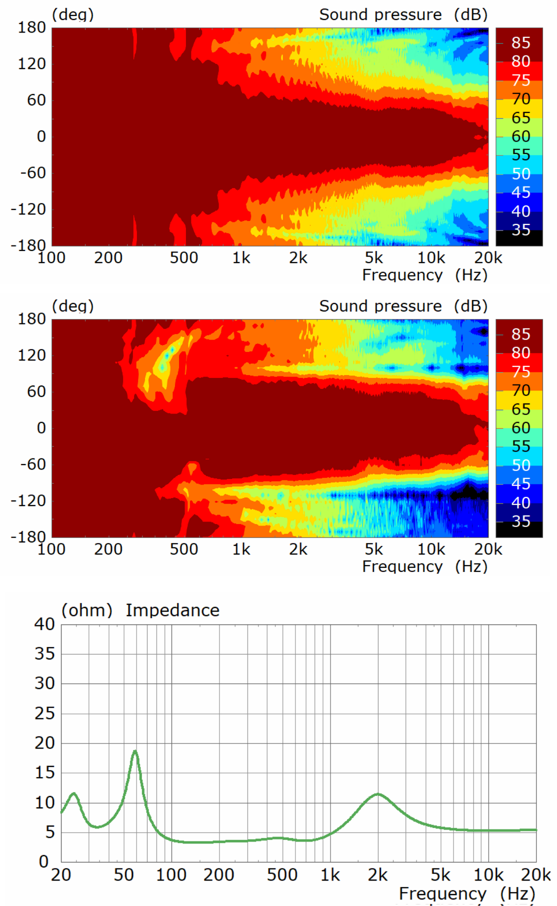
Three-way Floorstanding Loudspeaker



Q11 Meta Spinorama

Technical Specifications

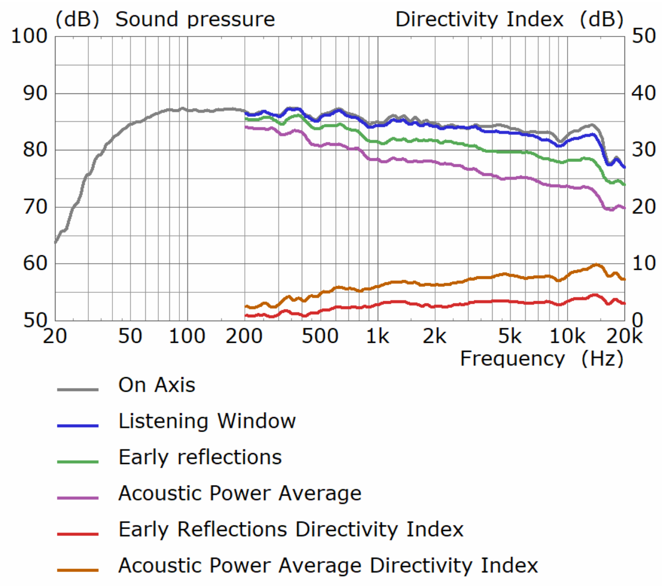
System	Three-way bass reflex
Drive units	Uni-Q Driver Array: HF: 19 mm (0.75 in.) vented aluminium dome with MAT MF: 100 mm (4 in.) aluminium cone Bass Drivers: LF: 3 x 165mm (6.5 in.) aluminium cone
Frequency range free-field (-6dB)	37Hz - 20kHz
Typical in-room bass response (-6dB)	26Hz
Frequency response (±3dB)	44Hz - 20kHz
Crossover frequencies	480Hz, 2.7kHz
Recommended amplifier power	15-225W
Sensitivity (2.83V/1m)	89dB
Harmonic distortion 2nd & 3rd harmonics (90dB, 1m)	<2% 29Hz and above <1% 31Hz - 20kHz
Maximum output (Peak sound pressure level at 1m with pink noise)	113dB
Impedance	4 Ω (min. 3.2 Ω)
Weight	22.5kg (49.6 lbs)
Dimensions with plinth (H x W x D)	1112 x 317 x 380 mm (43.8 x 12.5 x 15 in.)



Q11 Meta directivity contours - horizontal (top) and vertical (middle) - and impedance (bottom)

Q7 Meta

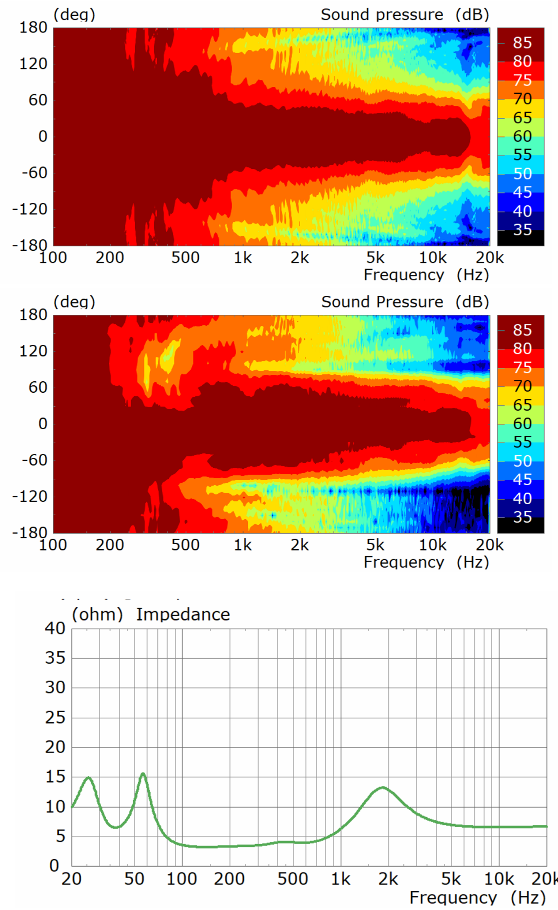
Three-way Floorstanding Loudspeaker



Q7 Meta Spinorama

Technical Specifications

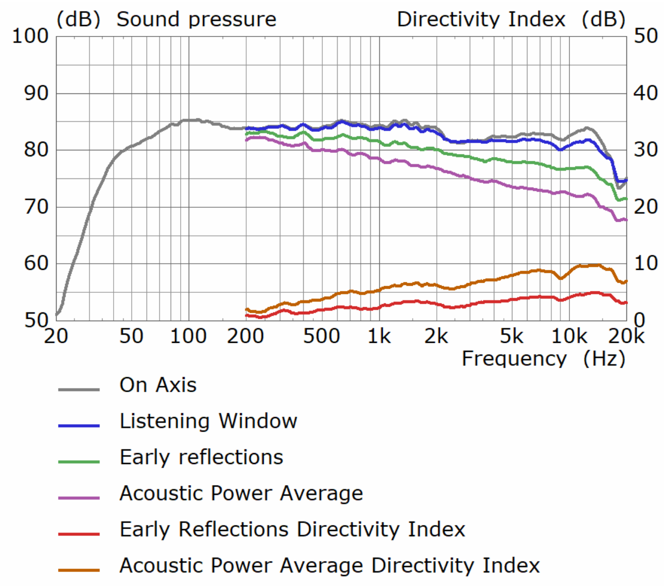
System	Three-way bass reflex
Drive units	Uni-Q Driver Array: HF: 19 mm (0.75 in.) vented aluminium dome with MAT MF: 100 mm (4 in.) aluminium cone Bass Drivers: LF: 2 x 165mm (6.5 in.) aluminium cone
Frequency range free-field (-6dB)	39Hz - 20kHz
Typical in-room bass response (-6dB)	28Hz
Frequency response (±3dB)	46Hz - 20kHz
Crossover frequencies	440Hz, 2.3kHz
Recommended amplifier power	15-200W
Sensitivity (2.83V/1m)	87dB
Harmonic distortion 2nd & 3rd harmonics (90dB, 1m)	<2% 35Hz and above <1% 38Hz - 20kHz
Maximum output (Peak sound pressure level at 1m with pink noise)	110dB
Impedance	4 Ω (min. 3.2 Ω)
Weight	18.4kg (40.6 lbs)
Dimensions with plinth (H x W x D)	1001 x 317 x 315 mm (39.4 x 12.5 x 12.4 in.)



Q7 Meta directivity contours - horizontal (top) and vertical (middle) - and impedance (bottom)

Q Concerto Meta

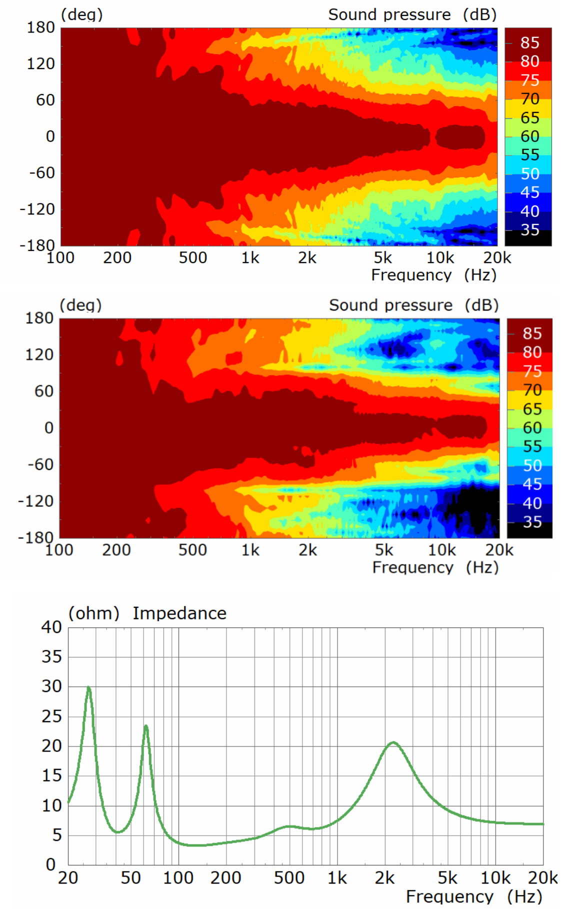
Three-way Bookshelf Loudspeaker



Q Concerto Meta Spinorama

Technical Specifications

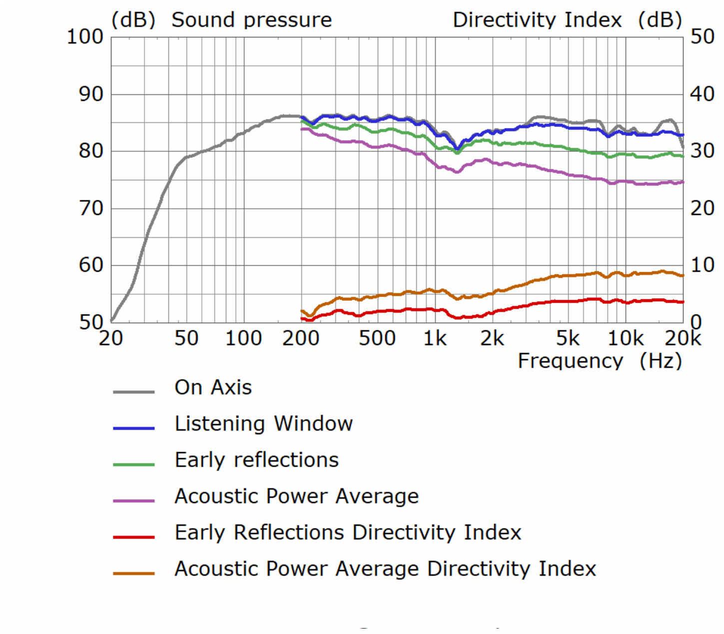
System	Three-way bass reflex
Drive units	Uni-Q Driver Array: HF: 19 mm (0.75 in.) vented aluminium dome with MAT MF: 100 mm (4 in.) aluminium cone Bass Drivers: LF: 165mm (6.5 in.) aluminium cone
Frequency range free-field (-6dB)	40Hz - 20kHz
Typical in-room bass response (-6dB)	36Hz
Frequency response (±3dB)	48Hz - 20kHz
Crossover frequencies	430Hz, 2.9kHz
Recommended amplifier power	15-180W
Sensitivity (2.83V/1m)	85dB
Harmonic distortion 2nd & 3rd harmonics (90dB, 1m)	<2% 37Hz and above <1% 91Hz - 20kHz
Maximum output (Peak sound pressure level at 1m with pink noise)	108dB
Impedance	4 Ω (min. 3.2 Ω)
Weight	9.5kg (20.9 lbs)
Dimensions with terminal (H x W x D)	415 x 210 x 315 mm (16.3 x 8.3 x 12.4 in.)



Q Concerto Meta directivity contours - horizontal (top) and vertical (middle) - and impedance (bottom)

Q4 Meta

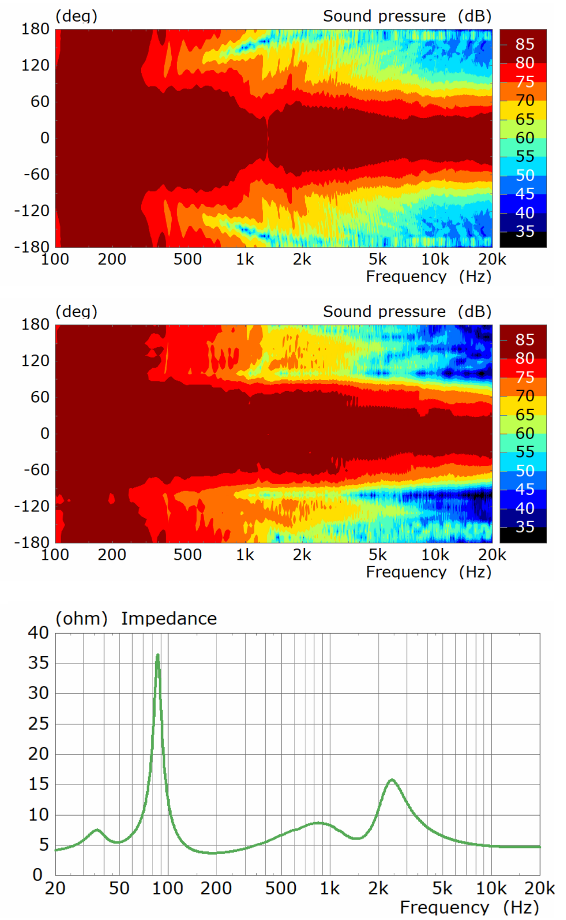
Two-way On-Wall Loudspeaker



Q4 Meta Spinorama

Technical Specifications

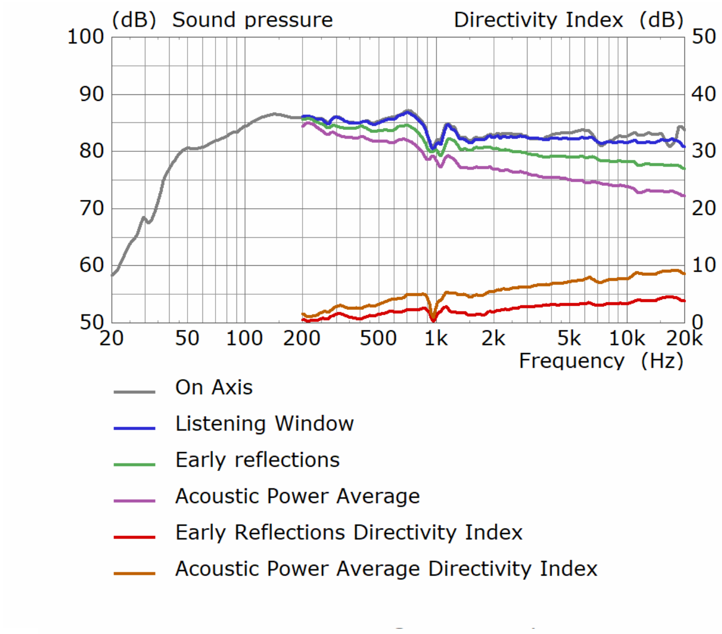
System	Two-way bass reflex
Drive units	Uni-Q Driver Array: HF: 25 mm (1 in.) vented aluminium dome with MAT LF/MF: 130 mm (5.25 in.) aluminium cone
Frequency range free-field (-6dB)	52Hz - 20kHz
Typical in-room bass response (-6dB)	44Hz
Frequency response (±3dB)	65Hz - 20kHz
Crossover frequencies	1.8kHz
Recommended amplifier power	10-150W
Sensitivity (2.83V/1m)	86dB
Harmonic distortion 2nd & 3rd harmonics (90dB, 1m)	<2% 145Hz and above <1% 170Hz - 20kHz
Maximum output (Peak sound pressure level at 1m with pink noise)	108dB
Impedance	4 Ω (min. 3.2 Ω)
Weight	5.7kg (12.6 lbs)
Dimensions with terminal (H x W x D)	400 x 250 x 142 mm (15.7 x 9.8 x 5.6 in.)



Q4 Meta directivity contours - horizontal (top) and vertical (middle) - and impedance (bottom)

Q3 Meta

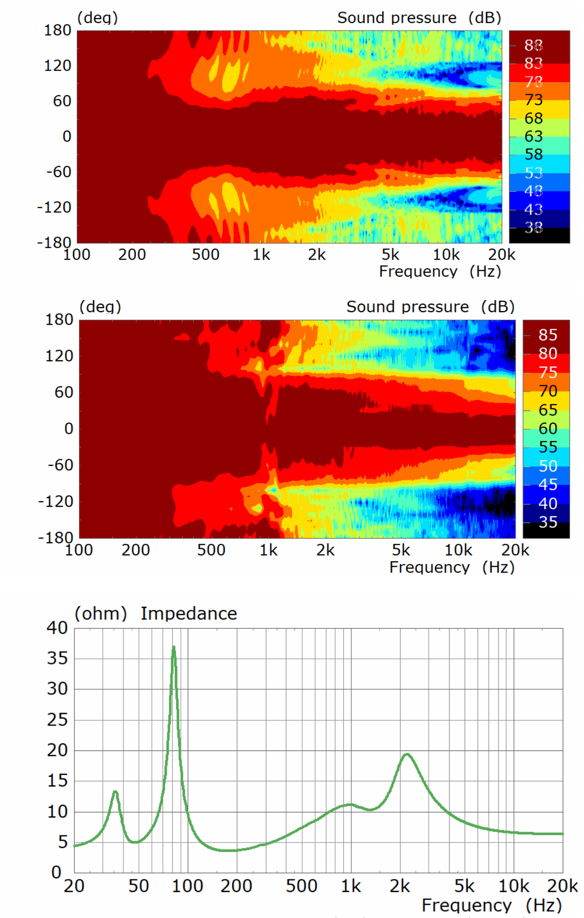
Two-way Bookshelf Loudspeaker



Q3 Meta Spinorama

Technical Specifications

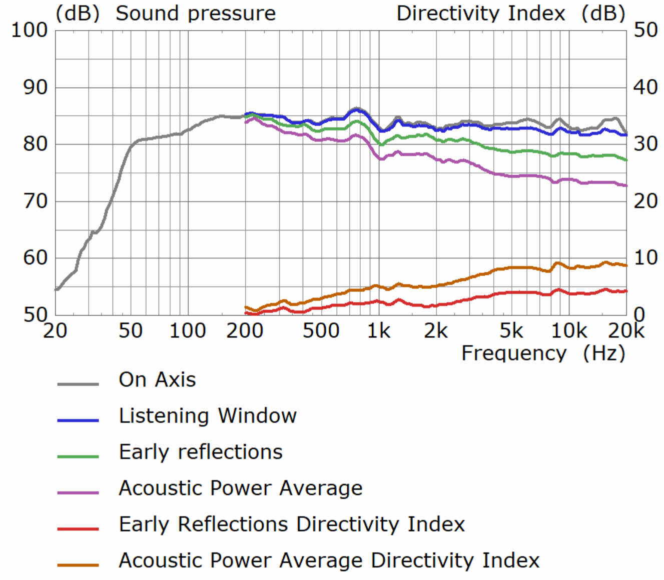
System	Two-way bass reflex
Drive units	Uni-Q Driver Array: HF: 25 mm (1 in.) vented aluminium dome with MAT LF/MF: 160 mm (6.5 in.) aluminium cone
Frequency range free-field (-6dB)	42Hz - 20kHz
Typical in-room bass response (-6dB)	39Hz
Frequency response (±3dB)	49Hz - 20kHz
Crossover frequencies	2.0kHz
Recommended amplifier power	15-150W
Sensitivity (2.83V/1m)	87dB
Harmonic distortion 2nd & 3rd harmonics (90dB, 1m)	<2% 110Hz and above <1% 135Hz - 20kHz
Maximum output (Peak sound pressure level at 1m with pink noise)	109dB
Impedance	4 Ω (min. 3.2 Ω)
Weight	8.2kg (18.1 lbs)
Dimensions with terminal (H x W x D)	357 x 210 x 305 mm (14.1 x 8.3 x 12.0 in.)



Q3 Meta directivity contours - horizontal (top) and vertical (middle) - and impedance (bottom)

Q1 Meta

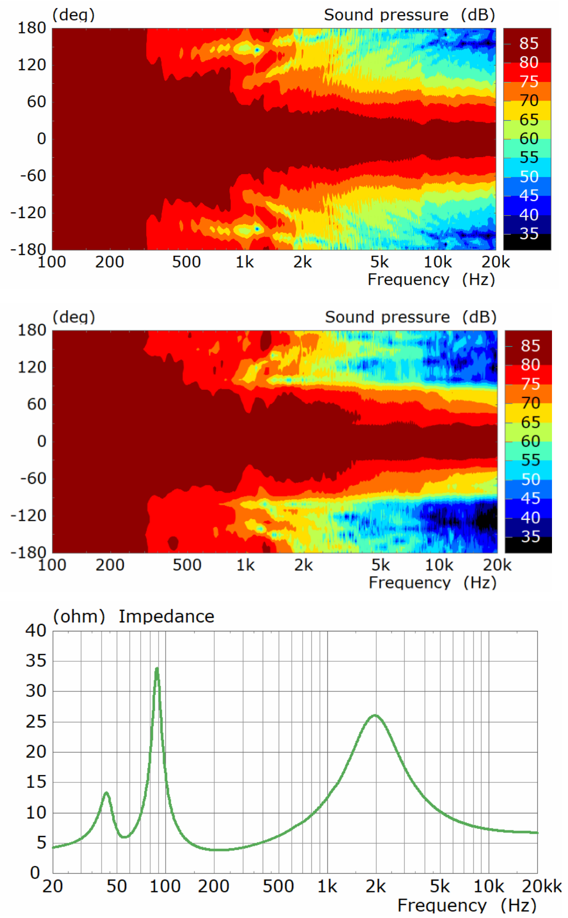
Two-way Bookshelf Loudspeaker



Q1 Meta Spinorama

Technical Specifications

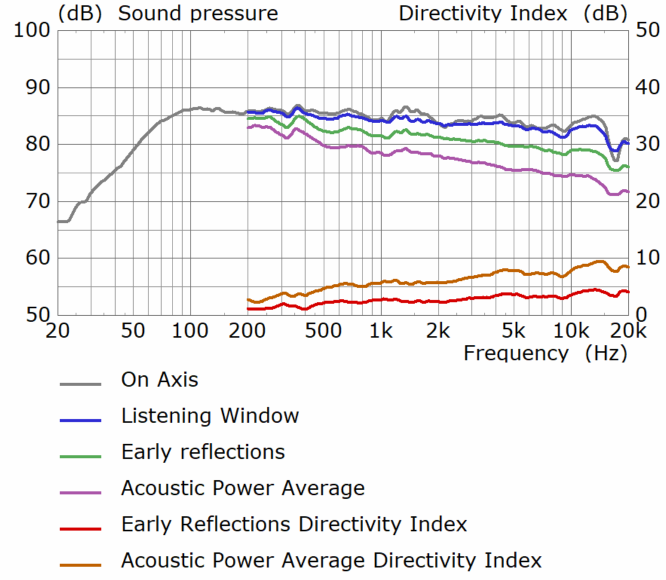
System	Two-way bass reflex
Drive units	Uni-Q Driver Array: HF: 25 mm (1 in.) vented aluminium dome with MAT LF/MF: 130 mm (5.25 in.) aluminium cone
Frequency range free-field (-6dB)	47Hz - 20kHz
Typical in-room bass response (-6dB)	42Hz
Frequency response (±3dB)	51Hz - 20kHz
Crossover frequencies	2.1kHz
Recommended amplifier power	10-150W
Sensitivity (2.83V/1m)	86dB
Harmonic distortion 2nd & 3rd harmonics (90dB, 1m)	<2% 140Hz and above <1% 170Hz - 20kHz
Maximum output (Peak sound pressure level at 1m with pink noise)	108dB
Impedance	4 Ω (min. 3.2 Ω)
Weight	6.1kg (13.4 lbs)
Dimensions with terminal (H x W x D)	302 x 180 x 277 mm (11.9 x 7.1 x 10.9 in.)



Q1 Meta directivity contours - horizontal (top) and vertical (middle) - and impedance (bottom)

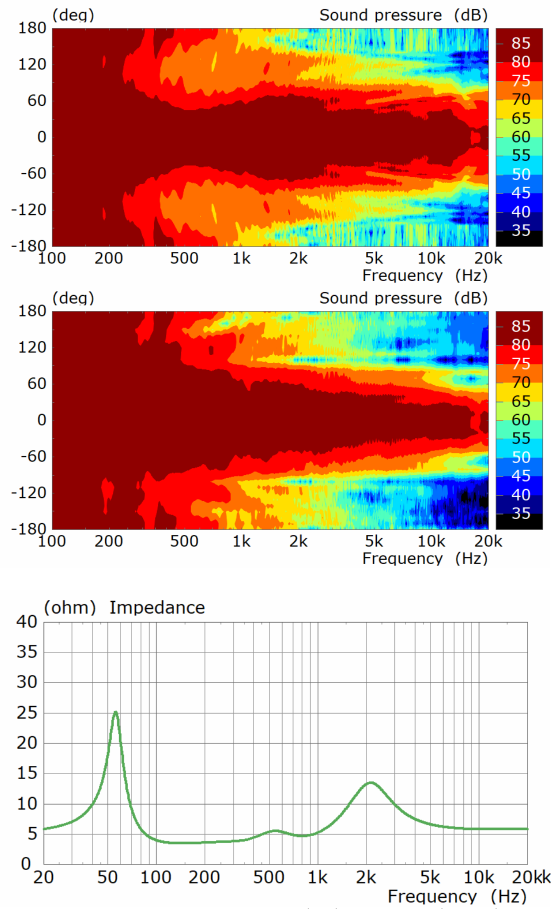
Q6 Meta

Three-way LCR Loudspeaker



Q6 Meta Spinorama

System	Three-way closed box
Drive units	Uni-Q Driver Array: HF: 19 mm (0.75 in.) vented aluminium dome with MAT MF: 100 mm (4 in.) aluminium cone Bass Drivers: LF: 2 x 130mm (5.25 in.) aluminium cone
Frequency range free-field (-6dB)	52Hz - 20kHz
Typical in-room bass response (-6dB)	36Hz
Frequency response (±3dB)	63Hz - 20kHz
Crossover frequencies	560Hz, 2.7kHz
Recommended amplifier power	15-200W
Sensitivity (2.83V/1m)	87dB
Harmonic distortion 2nd & 3rd harmonics (90dB, 1m)	<2% 20Hz and above <1% 68Hz - 20kHz
Maximum output (Peak sound pressure level at 1m with pink noise)	109dB
Impedance	4 Ω (min. 3.2 Ω)
Weight	14.1kg (31.1 lbs)
Dimensions with terminal (H x W x D)	210 x 609 x 303 mm (8.3 x 24.8 x 11.9 in.)



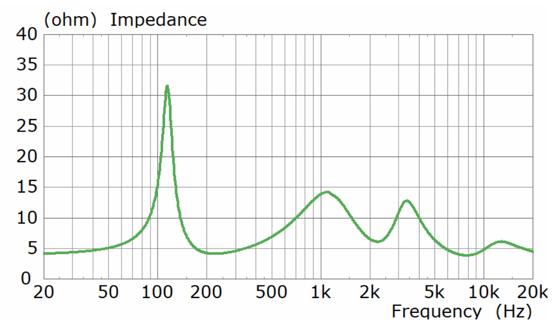
Q6 Meta directivity contours - horizontal (top) and vertical (middle) - and impedance (bottom)

Q8 Meta

Two-way surround/Dolby Atmos Loudspeaker

Technical Specifications

System	Three-way closed box
Drive units	Uni-Q Driver Array: HF: 25 mm (1 in.) vented aluminium dome with MAT LF/MF: 130 mm (5.25 in.) aluminium cone
Frequency range free-field (-6dB)	96Hz - 20kHz
Typical in-room bass response (-6dB)	90Hz
Frequency response (±3dB)	105Hz - 20kHz
Crossover frequencies	2.7kHz
Recommended amplifier power	1-150W
Sensitivity (2.83V/1m)	86dB
Harmonic distortion 2nd & 3rd harmonics (90dB, 1m)	<2% 145Hz and above <1% 170Hz - 20kHz
Maximum output (Peak sound pressure level at 1m with pink noise)	109dB
Impedance	4 Ω (min. 3.2 Ω)
Weight	4.5kg (9.9 lbs)
Dimensions with terminal (H x W x D)	176 x 180 x 259 mm (6.9 x 7.1 x 10.2 in.)



Q6 Meta impedance

KEF