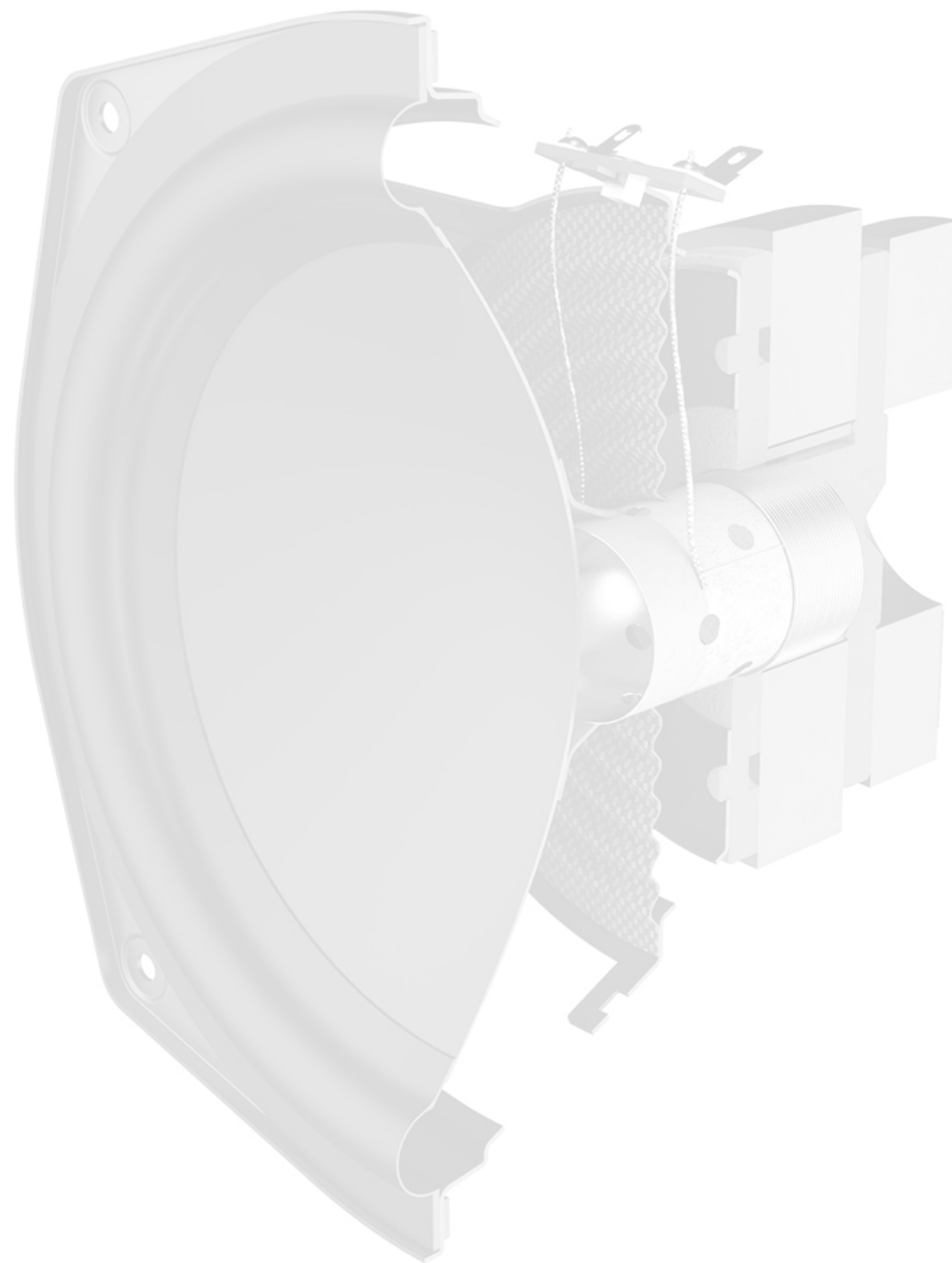




# 3000c SERIES

WHITE PAPER



## Introduction

The design process for a new range from Q Acoustics begins with a thorough review of the available technologies we have and how we can improve performance to take the art of loudspeaker design one step further.

Our most recent technology breakthrough is the development of the remarkable Continuous Curved Cone (C<sup>3</sup>) mid/bass cone profile. Featuring a cone that exhibits the bass characteristics of a straight conic profile and the mid frequency control of a flared profile, the distinctive C<sup>3</sup> shape features in all models in the new 3000c series.

This document describes in technical detail the project history of the C<sup>3</sup> profile, the subsequent development task required to incorporate this technology into mid/bass drivers and the other supporting technologies that are an essential part in providing a step-change in performance for this all new 3000c range.



## The C<sup>3</sup> project

First developed to enhance the performance of the Q Acoustics 5000 series, the benefits of the unique profile of C<sup>3</sup> have now been introduced into a set of all-new mid/bass drivers to power the 3000c series.

The profile of a mid/bass driver cone has always been a compromise. Whilst a straight conic profile has benefits at bass frequencies, it exhibits undesirable break-up modes that will restrict its higher frequency range. A flared cone is a better option to control the cone break-up towards higher frequencies, however the flare shape will not hold its rigidity at low frequencies so well as a straight conic shape, particularly at the outer diameter.

The C<sup>3</sup> profile is the result of a Q Acoustics multi-disciplinary team research project to investigate a new, complex curve contour cone profile. The goal was to design a profile that would exhibit 'best of both' benefits with the bass characteristics of a straight conic profile, and with the mid frequency control of a flared profile.

At the outset, the C<sup>3</sup> project began by computer-modelling a sample drive unit with a spherical cone driven by a large coupler. This is the 'anchor model' shown in Figure 1. The anchor model and its respective measurements form the starting point for any kind of new development. To start the development process the anchor-model's simulation results must accurately predict the measurements of the sample. Therefore the geometry and the material properties of each soft-part (cone, coupler, surround, spider, voice-coil) have to be identified and adjusted to achieve an accurate alignment between the measurements and the simulation results.

Figure 2 shows a 2-radius cone profile, the first step towards the C<sup>3</sup> profile. This was the first shape for which tooling was made and samples were built. The measurement results of each sample

were used to refine the Finite Element Analysis (FEA) model and thus increase the prediction accuracy.

The next phase was to investigate the integration of the multiple radii into a single, smooth, continuous curve profile. An example of a continuous curve cone is shown in Figure 3. Computer modelling continued until the performance of these smooth transition C<sup>3</sup> profiles had been optimised and were ready to prototype and test. Further modelling and prototypes of adjustments to that profile yielded even better performance.

With prototypes of a refined, new C<sup>3</sup> cone now available, the final phase of the drive unit design could begin as, in common with all other Q Acoustics drive units, they are clean sheet designs. Every component part is a unique design and not a standard part in any way. Performance trials continued to optimise components such as the roll surround, spider and the interface between these components and the C<sup>3</sup> cone to achieve the required performance levels and also durability. Between the start and the finish of the project sixteen different samples had been evaluated. The variations covered the cone-shape, surround-thickness, spider-geometry and the optional use of a coupler between the cone and the voice coil.

The first drive unit design had now reached a stage where manufacturing tooling could begin, but it had become apparent that the profile of C<sup>3</sup> cannot just be scaled for different diameter drive units. Work commenced to create derivative profiles for both larger and smaller diameter cones. With accurate computer models this had become a much quicker process.

The project saw completion with the release of the acclaimed Q Acoustics 5000 series loudspeakers, the first to include C<sup>3</sup> technology for the mid/bass drivers.



**Figure 1**



**Figure 2**



**Figure 3**

### Technical benefits of C<sup>3</sup> Continuous Curved Cone™

With excellent dispersion, a drive unit with a C<sup>3</sup> cone features a well controlled frequency response which enables smooth integration with the high-frequency driver using gentle slope, low order crossovers.

Frequency and amplitude linearity performance are exceptional for a drive unit in this class as shown in the plot of the 3000c series 120 mm driver of the 3020c in Figure 4. Harmonic artefacts can be seen to be well below the 0.4 % limit line for most of the critical midband.

A further side benefit of C<sup>3</sup> implementation is that the cone is more resilient to modulation by standing-waves within the cabinet.

### C<sup>3</sup> Continuous Curved Cone™ benefits in audition

The benefits of a drive unit featuring C<sup>3</sup> are not subtle, and can particularly be heard as excellent bass dynamics, significantly better than single radius flared cones. The C<sup>3</sup> profile does exhibit the best characteristics of a simple, straight conic profile, but without its undesirable break-up modes.

The tight, damped bass sound of loudspeaker designs featuring C<sup>3</sup> drive units enables more flexibility in placement of speakers near the boundaries of the listening room. Subjectively the drive units appear to be more in control of the room space, rather than the room exciting the loudspeaker.

### Conclusion

It is rare that a genuine advance is made to one of the fundamental design elements of a loudspeaker drive unit. Most progress in loudspeaker design is incremental, based on the use of more advanced materials etc, but the C<sup>3</sup> profile has successfully addressed shortcomings in one of the basic geometrical elements of drive unit design.

Not to be confused with other one-piece cone designs that simply integrate a dust-cap into the cone profile, the final C<sup>3</sup> profile delivers genuine technical performance benefits over traditional industry standard cone profiles.

In this case the C<sup>3</sup> project has achieved the team's objective to design a loudspeaker cone that will deliver the best characteristics of both straight and flared cones.

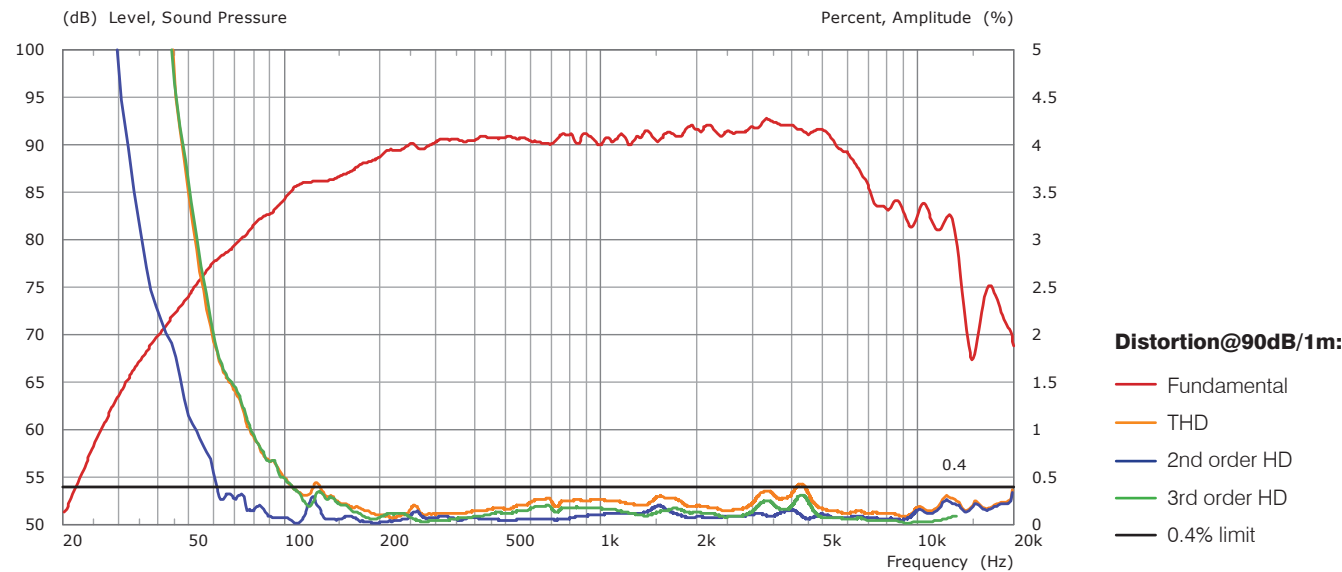


**Figure 4**

## Drive units

### Mid/Bass drive unit construction

A radical re-design from the mid/bass drivers of the previous range, every component is new, with C<sup>3</sup> cones and larger motors than the equivalent 3000i driver. Three sizes cover the range:

- 101 mm (3010c, 3090c)
- 120 mm (3020c)
- 142 mm (3030c, 3050c)

System designs incorporating the C<sup>3</sup> geometry require bass/mid drivers with good motor strength and high BL. These powerful motors achieve a high degree of saturation for the pole plate. This reduces harmonic distortion as there is less unsaturated iron to be modulated by the coil flux.

The increased magnet dimensions are:

- 85 mm x 18 mm (3010c and 3090c)
- 90 mm x 18 mm (3020c)
- 90 mm x 18 mm + 80 mm x 15 mm (3030c, 3050c)

The magnets are paired with 25.5 mm voice coils.

The voice coils for the higher power 3020c, 3030c and 3050c models are wound from Copper-Clad Aluminium Wire (CCAW) over a glass fibre former. The lightweight CCAW wire keeps the moving mass low while the non-conductive former completely eliminates eddy currents which can otherwise be induced in aluminium voice coil formers.

The cone material, the voice coil construction and optimised suspension system are all design features inherited from the Q Acoustics Concept mid/bass driver.

The low damping, pure nomex spider results in good dynamic behaviour, especially for small signals. FEA computer modelling techniques were used to optimise the design of the spider and

surround for a symmetric compliance characteristic and to achieve best alignment of the suspension with the new motor system.

Key features are shown in Figure 5, a cutaway view of the drive unit construction.

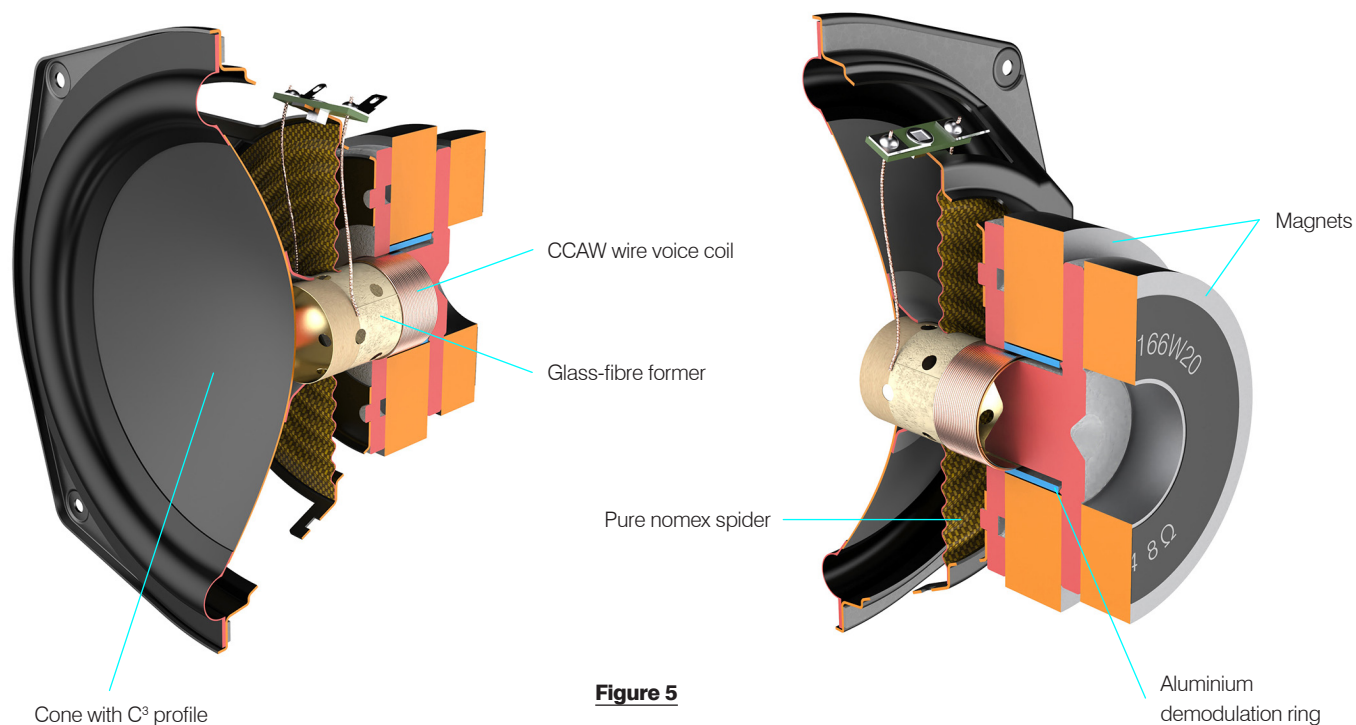


**Figure 5**

### Mid/Bass drive unit performance

The symmetric shape of the measured  $Bl(x)$  and  $Cms(x)$  graphs for the 3020c 120 mm mid/bass driver are shown in Figures 6 and 7 and prove that the targeted design goals have been achieved. The symmetry of these curves assures: low harmonic distortion at low frequencies and high excursions and a well defined rest-position for the voice-coil.

To complete the design, an aluminium demodulation ring is mounted underneath the pole-plate for reduced inductance induced modulation distortion. In Figure 8 the measured coil inductance  $L(x)$  is plotted as a function of excursion. The increase in  $L_e(x)$  at negative deflections, which is typical of uncompensated motor systems, is avoided, resulting in reduced distortion modulation in the mid-range, confirming that the 3000c series mid/bass drivers perform well in this regard.

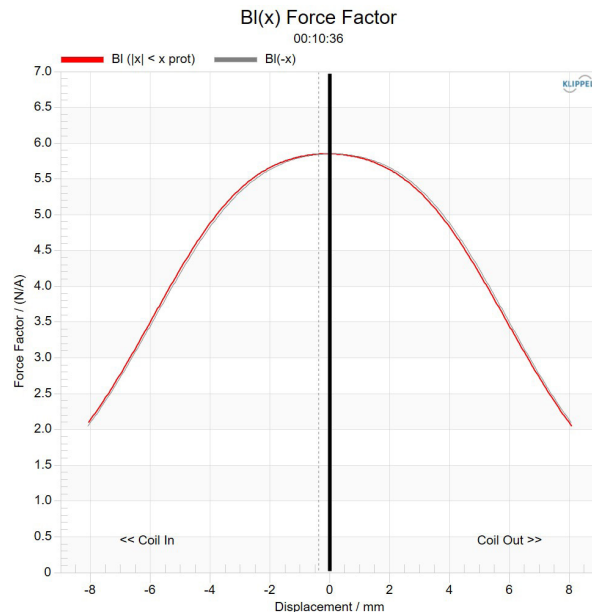


**Figure 6**

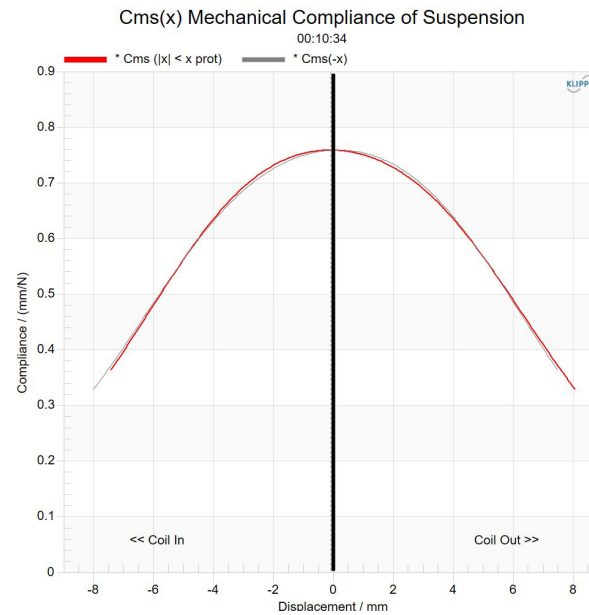


**Figure 7**

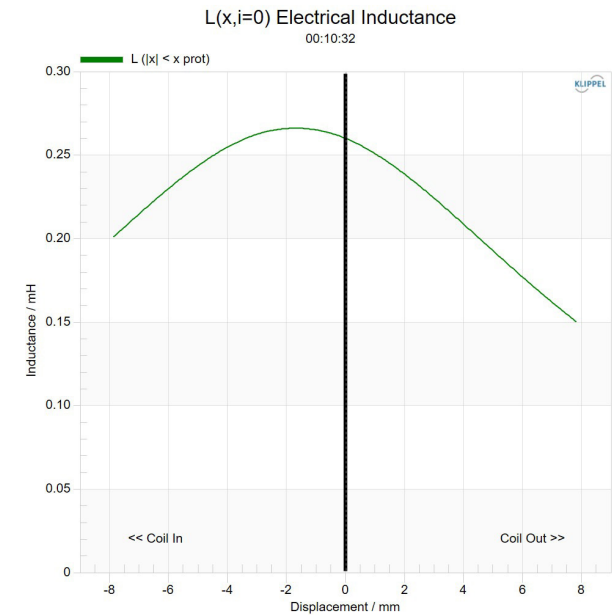


**Figure 8**

### High frequency drive unit construction

Inheriting design benefits from the Concept and 5000 ranges, the 3000c series high-frequency driver sits in a compliant mounting, within a housing cup, to mechanically isolate it from the front baffle.

In addition, the high-frequency driver is hermetically sealed to prevent modulation by pressures from within the cabinet.

Two sizes are employed in the 3000c range:

- 50 mm (3010c, 3020c, 3090c)
- 60 mm (3030c, 3050c)

Finite element analysis was used to model the acoustic performance of the polyester micro-fibre soft-dome high-frequency drive units. The extra-wide surround of the high-frequency drive units contributes to wide and even dispersion of upper frequencies, adding extra energy off axis.

The light-weight 22 mm soft domes, combined with a double ferrite magnet gives the high-frequency driver a high sensitivity and a flat frequency response right up to 30 kHz making the unit ideal for hi-res musical material.

Linearity is ensured by incorporating balanced-pressure design characteristics into the internal structure of the drive unit. Minute imbalances of pressure can cause audible problems at high frequencies and the unit is so designed that the internal pressures are always equalised within the soft dome.

Key features are shown in Figure 9, a cutaway view of the drive unit construction.

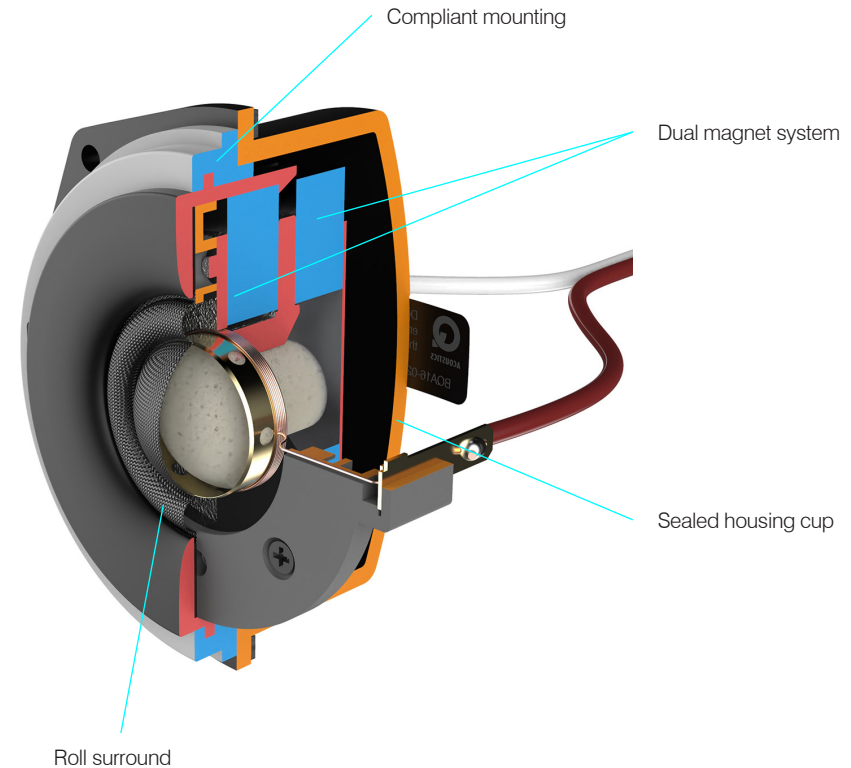


**Figure 9**

### High frequency drive unit performance

Designed with a 800 Hz resonant frequency the bandwidth of the high-frequency driver is optimised to allow a low crossover point around 2.5 kHz. This maximises the off axis performance of the Mid/Bass - Tweeter - Mid/Bass (MTM) design of the 3050c and 3090c and maintains phase consistency for seamless integration through the crossover region. Figure 10 shows the on-axis SPL and THD for the 3020c high-frequency driver measured at 90 dB/1m.

A measured THD value of less than 0.2% for frequencies above 1.5 kHz confirms that this is a low distortion, high excursion high-frequency driver, well suited to a low crossover frequency. The wide roll-surround design delivers a broader directivity and phase-coherent off-axis radiation. A shallow wave guide improves the directivity of the high-frequency driver in the 5-15 kHz region as shown in the directivity diagram in Figure 11.

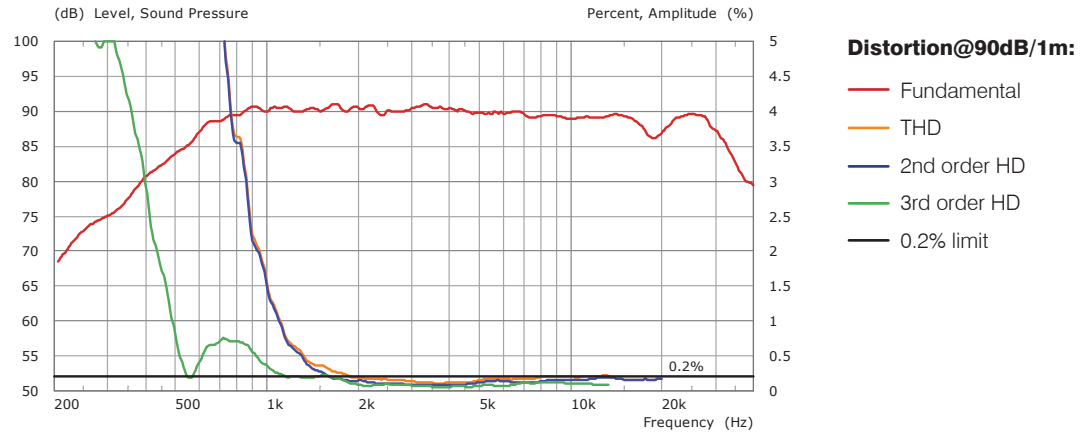


**Figure 10**

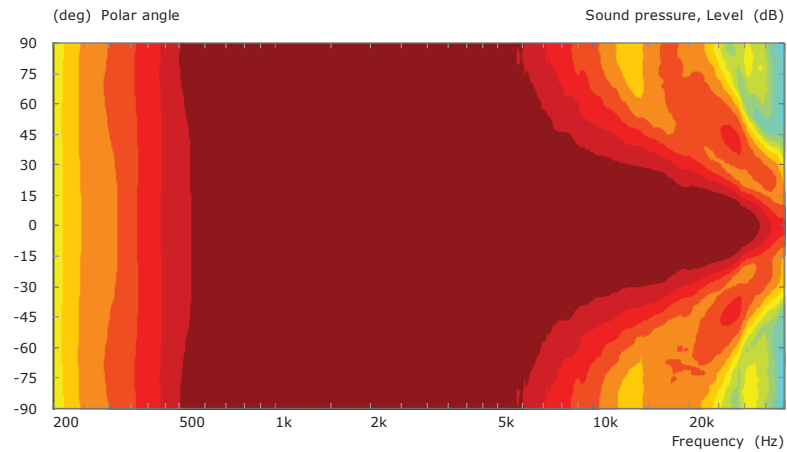


**Figure 11**

# Cabinet

## Cabinet construction

The cabinets are constructed from 16mm Medium Density Fibreboard (MDF). To give strength where it is needed, all baffles are 25 mm High Density Fibreboard (HDF).

All cabinets feature Point to Point (P2P) bracing to brace the cabinet structure exactly where required to stiffen the cabinet and reduce panel resonance with minimal intrusion into the cabinet volume. The 3050c includes an additional brace to strengthen the cabinet in the mounting area for the high-frequency driver. Refer to page 10 for more details of P2P bracing.

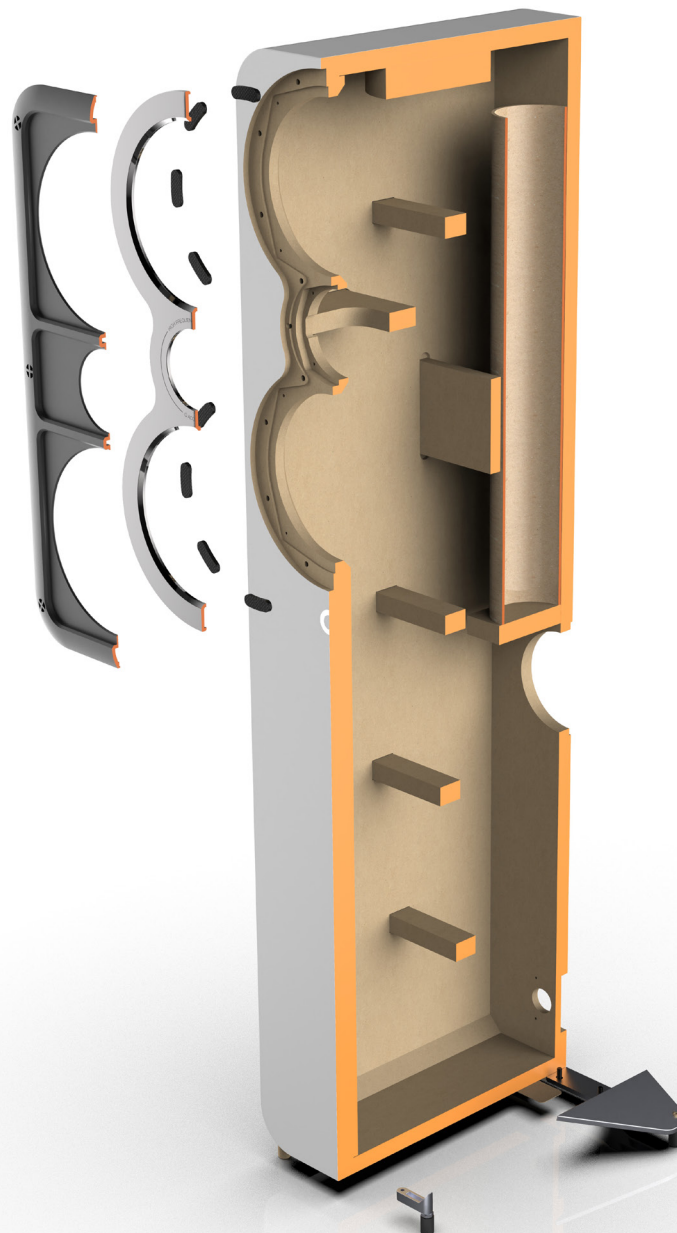
The 3050c includes a Helmholtz Pressure Equaliser (HPE) to reduce standing waves which can occur in tower profile speaker designs. Refer to page 11 for more details of HPE technology.

The 3010c, 3020c, 3030c and 3090c are supplied with threaded inserts in the base to provide secure fixing to compatible Q Acoustics stands and wall-brackets.

The 3050c includes die-cast aluminium stabilisers, spikes and protective spike covers that can be fitted if required to protect flooring. The stabilisers feature top adjustable spikes for easier levelling.

The 3000c series is available in four durable, high quality finishes - satin black, satin white, claro walnut and pin oak.

The satin metallic finish of the baffle cosmetic trim complements the aesthetic of the cabinet and the cabinet colour. The trims are compliant bonded to the front baffle to suppress vibration occurring in the baffles. The bonded trim and magnetic fixings for the grille enable a cosmetically clean and acoustically smooth front presentation to be achieved, uninterrupted by any fixings.



## P2P™ (Point to Point™) bracing

Q Acoustics P2P™ (Point to Point™) bracing is employed in all cabinets of the 3000c series.

P2P™ bracing is a cabinet bracing system that supports specific parts of the cabinet that need to be stiffened without coupling unwanted energy or exacerbating cabinet structure modality. P2P™ bracing will improve the focus of the stereo image and provide additional soundstage image.

The illustrations show how effective this methodology has become. Relative displacement simulations of 3050c cabinets without P2P™ bracing is shown in the left images in Figures 12, 13 and 14 at test frequencies of 335 Hz, 422 Hz and 474 Hz respectively.

Where displacement is greatest the area is coloured towards the red end of the spectrum and where it is least it is coloured towards the blue end. Conventional bracing would allow this movement to be transferred to adjacent panels, but Q Acoustics P2P™ allows the design team to apply bracing only in exactly the correct places.

When the simulations are repeated on the enclosures with P2P™ bracing, shown in the right images in Figures 12, 13 and 14, the deformation maps show how effectively the cabinet resonances have been reduced.

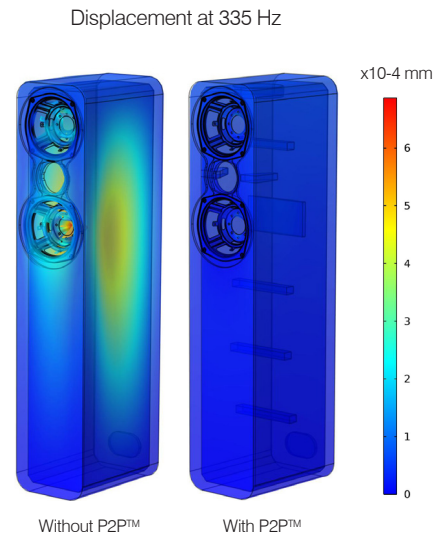


**Figure 12**

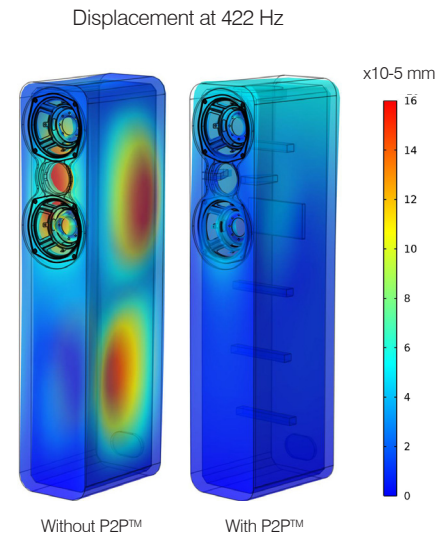


**Figure 13**

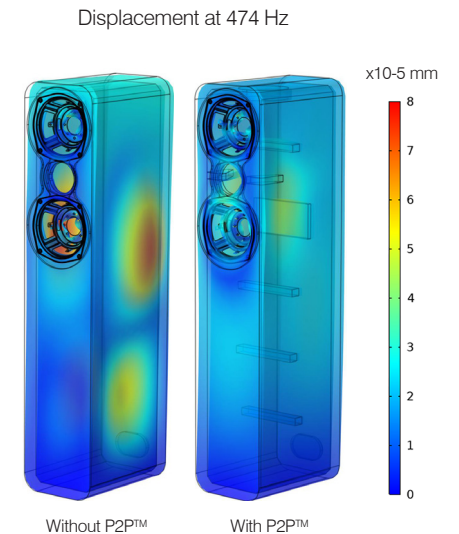


**Figure 14**

## HPE™ (Helmholtz Pressure Equalizer™) technology

The proportions of all tower format speakers can introduce undesirable standing waves within their cabinets. The 3050c tower therefore includes a Helmholtz Pressure Equaliser designed to convert pressure to velocity and reduce the overall pressure gradient within the enclosure.

The cutaway in Figure 15 shows the installation of HPE™ technology in a 3050c cabinet.

Figure 16 shows a sectional pressure map of a 3050c cabinet with and without HPE™.

The benefits of HPE™ technology can be clearly seen, significantly reducing the pressure gradient in the cabinet.

The benefits of HPE™ technology can also be measured in the frequency response curves. Figure 17 shows the frequency response of the 3050c cabinet measured without HPE™ (note the dip in the frequency response).

Figure 18 shows the improvement in frequency response with HPE™.

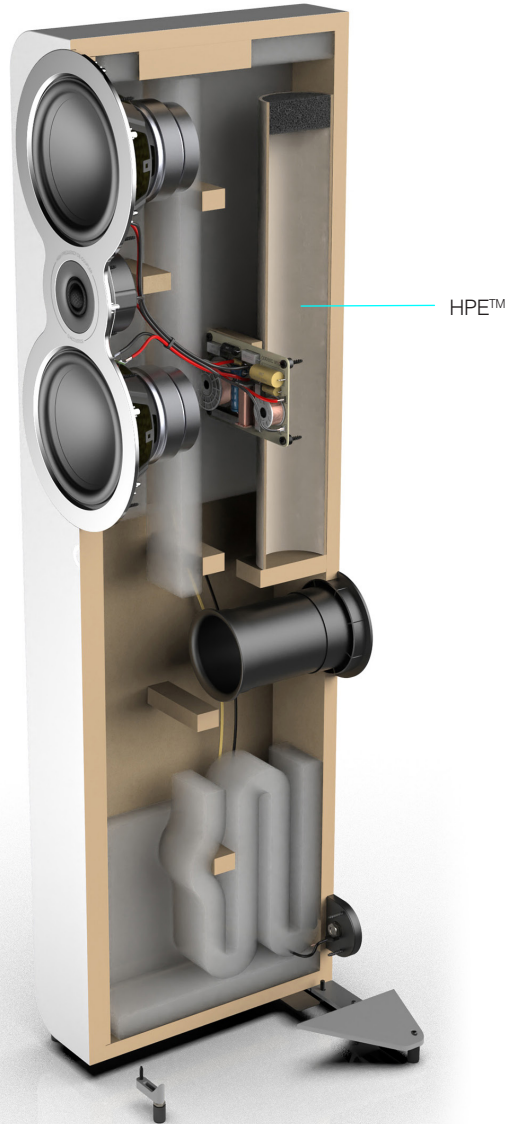


**Figure 15**

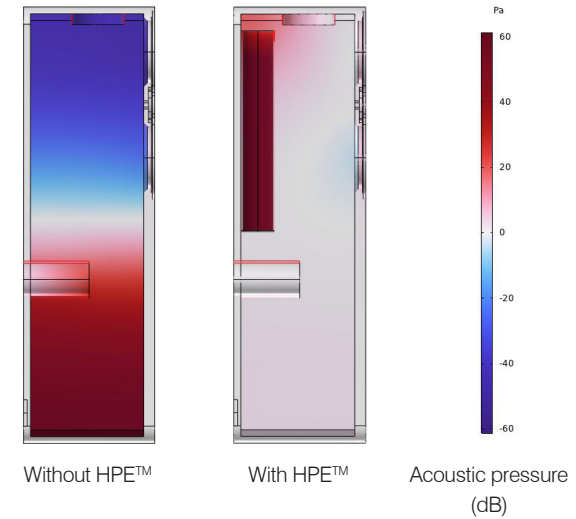


**Figure 16**

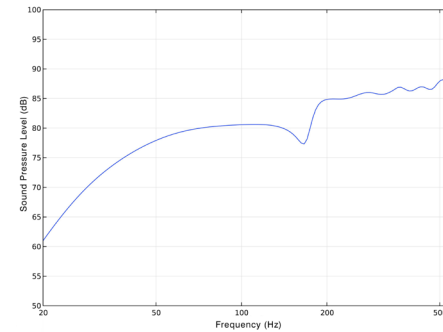


**Figure 17**

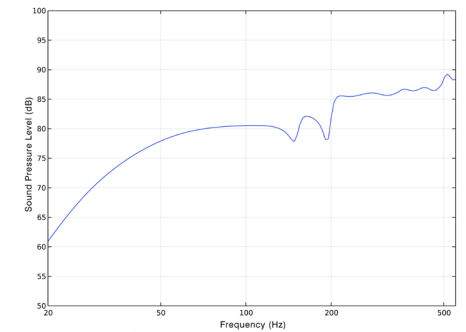


**Figure 18**

## Ports & Port Bungs

All cabinets in the range are ported designs. Low turbulence, flared ports are used throughout to minimise air noise that can occur on louder bass sounds with simpler port profiles. The ports in the 3010c, and 3090c (dual) are folded to optimise the length and inlet positioning for these designs. This port arrangement can be seen in the 3010c section view shown in Figure 19.

All 3000c series loudspeakers are rear-ported designs and should ideally be placed around 20cm from the back wall.

Where this is not possible, and shelf/bracket mounting or room considerations necessitate placement closer to a wall, a port 'bung' is supplied with each loudspeaker in the range (two bungs for the dual ports of the 3090c) as shown in Figure 20.

The port bung attenuates the bass output from the port, reducing the bass reinforcement that would otherwise take place if the port output was reflecting from the back wall.

The frequency response plots in Figure 21 are measured from a 3050c in free space and demonstrate the attenuation achieved by reducing port output when the port bung is fitted.

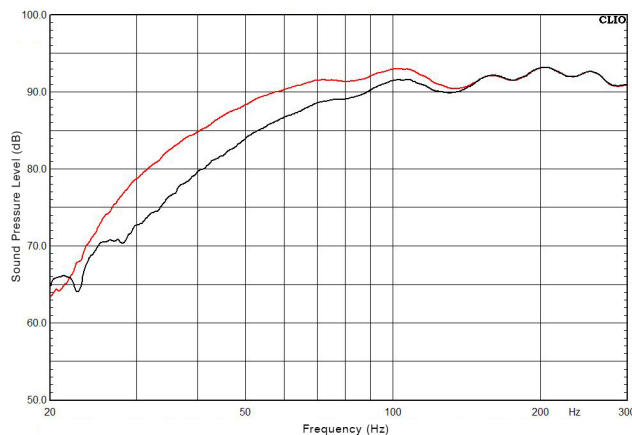


**Figure 21**

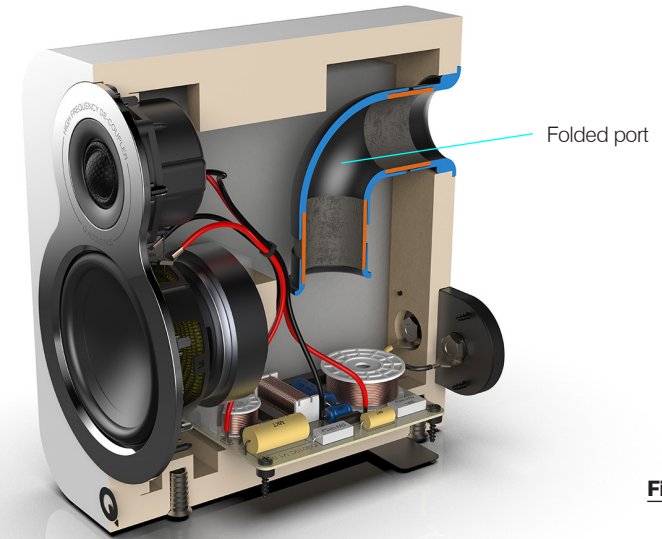


**Figure 19**

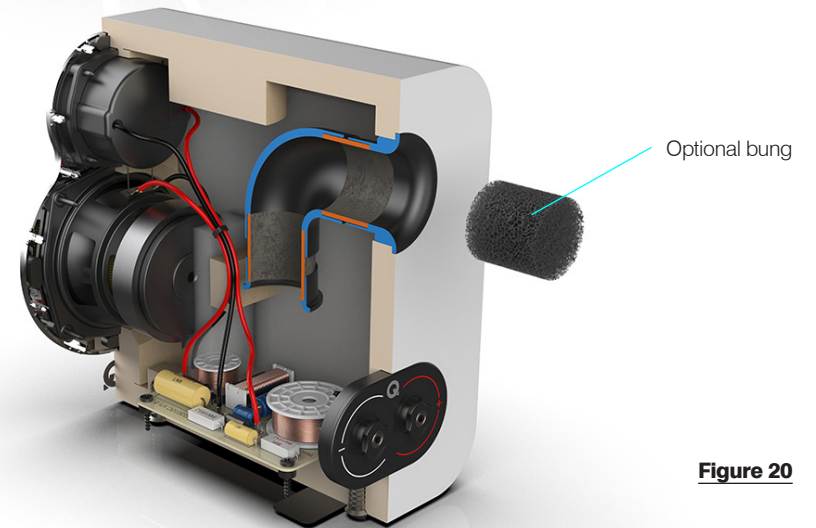
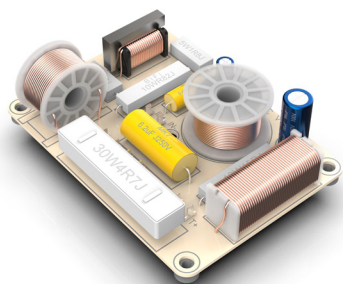


**Figure 20**



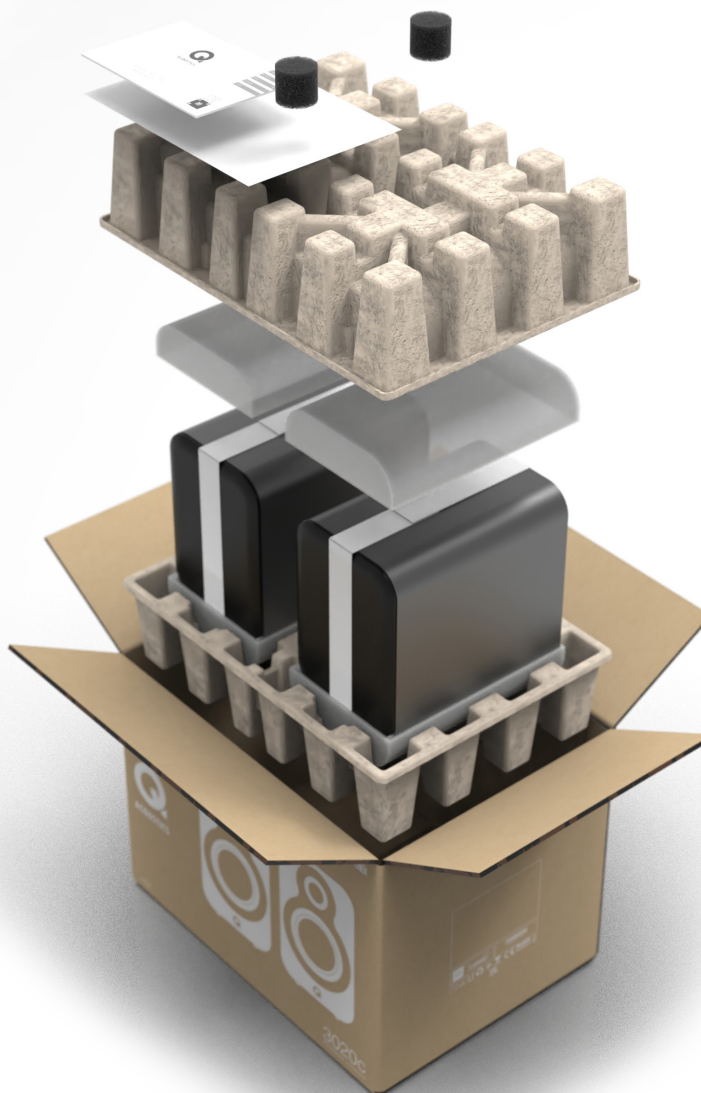
## Crossover

The crossovers are modified 2nd order designs with crossover points set for best integration between the mid/bass and high-frequency drivers in each of the models. The load impedance is set at a nominal 6 Ohms.



## Terminal panel

A new terminal pane features recessed terminals that are very low profile to keep plugs close to the speaker back face, providing a tidy appearance and enabling the speaker to be placed closer to the back wall if required.



## Packaging

Product packaging is responsible for conveying a product to the customer, safely and without damage from the rigours of shipping. When that journey is over, the packaging should be recycled so that the waste material can re-enter the supply chain and reduce the requirement for fresh, raw material.

To further improve the percentage of material that may be recycled from the 3000c series packaging, the entire range now features an all-new egg-crate packaging design, a first for Q Acoustics.

In this design, recycled cardboard pulp is used to manufacture the egg crate components and the fluted core of the carton, with just a layer of EPE film to protect the cabinet finish. The carton legends are applied with water-based inks.

The construction of the packaging yields an extremely high percentage of recyclable material at disposal. At least 97% of the packaging used for the 3000c range can now be recycled, compared to 80% for the range it replaces.

## Finishes

The 3000c series is available in four durable, high quality finishes - Satin Black, Satin White, Claro Walnut and Pin Oak.



Satin Black



Satin White



Claro Walnut



Pin Oak

## Accessories / Stands / Brackets



### Q FS50 speaker stand (pair)

Compatible with **3010c** and **3020c**

Precision laser-cut steel construction and acoustically damped columns ensure whatever the environment, you get the very best sound performance from your 3010c or 3020c speakers.

Available in a satin black or white finish.

#### Overall dimensions H/W/D

682 x 250 x 290 mm (26.9 x 9.8 x 11.4 in) per stand



### Q 3030FS speaker stand (pair)

Compatible with **3030c**

This speaker stand is designed for the latest 3030c loudspeaker – the largest standmount model in the series. Precision laser-cut steel construction and acoustically damped columns ensure a sonically optimised performance.

Available in a satin black or white finish.

#### Overall dimensions H/W/D

635 x 245 x 340 mm (25 x 9.6 x 13.4 in) per stand



### Q WB50 wall bracket (single)

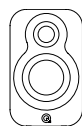
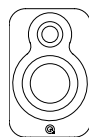
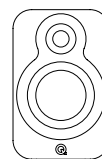
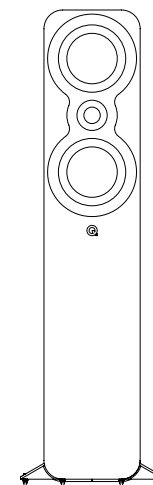
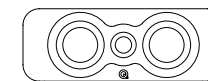
Compatible with **3010c**, **3020c** and **3090c**

This versatile wall bracket boasts a unique 'tilt and turn' mechanism, allowing a 3010c, 3020c and 3090c speaker to be mounted almost flat to the wall or angled down or sideways.

Available in black or white finishes.

*All stands and bracket include fixings compatible with the threaded inserts in the bases of the speakers to securely fix the speakers to the stands/brackets.*

## Specifications


**3010c**

**3020c**

**3030c**

**3050c**

**3090c**

|                                             |                                             |                                              |                                              |                                                                              |                                             |
|---------------------------------------------|---------------------------------------------|----------------------------------------------|----------------------------------------------|------------------------------------------------------------------------------|---------------------------------------------|
| <b>Bass unit</b>                            | 1 x 101 mm (4.0 in)                         | 1 x 120 mm (4.75 in)                         | 1 x 142 mm (5.5 in)                          | 2 x 142 mm (5.5in)                                                           | 2 x 101 mm (4.0 in)                         |
| <b>Treble unit</b>                          | 1 x 22 mm (0.9 in)                          | 1 x 22 mm (0.9 in)                           | 1 x 22 mm (0.9 in)                           | 1 x 22 mm (0.9 in)                                                           | 1 x 22 mm (0.9 in)                          |
| <b>Frequency response (-6 dB)</b>           | 60 Hz - 30 kHz                              | 60 Hz - 30 kHz                               | 48 Hz - 30 kHz                               | 42 Hz - 30 kHz                                                               | 68 Hz - 30 kHz                              |
| <b>Nominal impedance</b>                    | 6 Ω                                         | 6 Ω                                          | 6 Ω                                          | 6 Ω                                                                          | 6 Ω                                         |
| <b>Minimum impedance</b>                    | 3.7 Ω                                       | 3.7 Ω                                        | 3.9 Ω                                        | 3.8 Ω                                                                        | 3.7 Ω                                       |
| <b>Sensitivity (1 m, 2.83 Vrms @ 1 kHz)</b> | 85.0 dB                                     | 87.0 dB                                      | 86.5 dB                                      | 90.0 dB                                                                      | 92.0 dB                                     |
| <b>Recommended amplifier power</b>          | 15 - 80 W                                   | 25 - 90 W                                    | 25 - 90 W                                    | 25 - 150 W                                                                   | 25 - 120 W                                  |
| <b>Crossover frequency</b>                  | 3.1 kHz                                     | 2.6 kHz                                      | 2.5 kHz                                      | 2.4 kHz                                                                      | 2.9 kHz                                     |
| <b>Effective volume</b>                     | 4.5 L                                       | 6.9 L                                        | 12.5 L                                       | 41.6 L                                                                       | 6.8 L                                       |
| <b>Dimensions HxWxD (per loudspeaker)</b>   | 254 x 155 x 251 mm<br>(10.0 x 6.1 x 9.9 in) | 279 x 175 x 281 mm<br>(10.9 x 6.9 x 11.1 in) | 324 x 205 x 329 mm<br>(12.8 x 8.1 x 13.0 in) | Inc spikes and stabiliser:<br>1021 x 315 x 316 mm<br>(40.2 x 12.4 x 12.4 in) | 159 x 430 x 216 mm<br>(6.3 x 16.9 x 8.5 in) |
| <b>Weight (per loudspeaker)</b>             | 4.4 Kg (9.7 lbs)                            | 5.5 Kg (12.1 lbs)                            | 7.5 Kg (16.5 lbs)                            | 17.8 Kg (39.4 lbs)                                                           | 6.5 Kg (14.3 lbs)                           |