ACOUSTICS

Q Active

White Paper

Contents

Introduction

Design brief

The design brief for the Q Active system was to create an exceptional audio system within a pair of compact, high performance speakers, designed to fit seamlessly into a living environment. It was therefore decided early on in the design process to use wireless technologies to eliminate the wiring of a traditional audio system and require only the connection of mains power.

The brief included connectivity for essential sources such as network streaming, TV sound, and Bluetooth® audio. To enable connectivity with wired sources the system required a wireless speaker pair and a connection 'hub' that could be placed remotely for optimal installation. A wireless remote control would complete the system, avoiding the requirement for additional mobile apps, etc.

Each drive unit in Q Active was to be driven by a separate power amplifier and a dedicated digital signal processing (DSP) channel to provide equalisation. This DSP/active topology would enable a more radical approach for the acoustic design of Q Active.

The technologies developed for the Q Active range would be shared between the two speaker models; a compact floorstander (Q Active 400) and standmount (Q Active 200).

Whilst this is a fully featured audio system, Q Acoustics heritage is speaker design. This, the most important aspect of the system design, is the best place to start.

Speaker overview

Q Active speakers strike a harmony between industrial, electronic and acoustic design disciplines, applying creative solutions to perennial speaker design problems. The compact floorstander and standmount speakers both incorporate novel technologies and design features.

At the forefront of the design is the driver configuration, which impacts the entire layout of the speaker including cabinet structure and internal considerations to the electronics such as wireless module positioning and PCB design.

Figures 1 and 2 pinpoint the main mechanical features that are explored in detail throughout this paper.

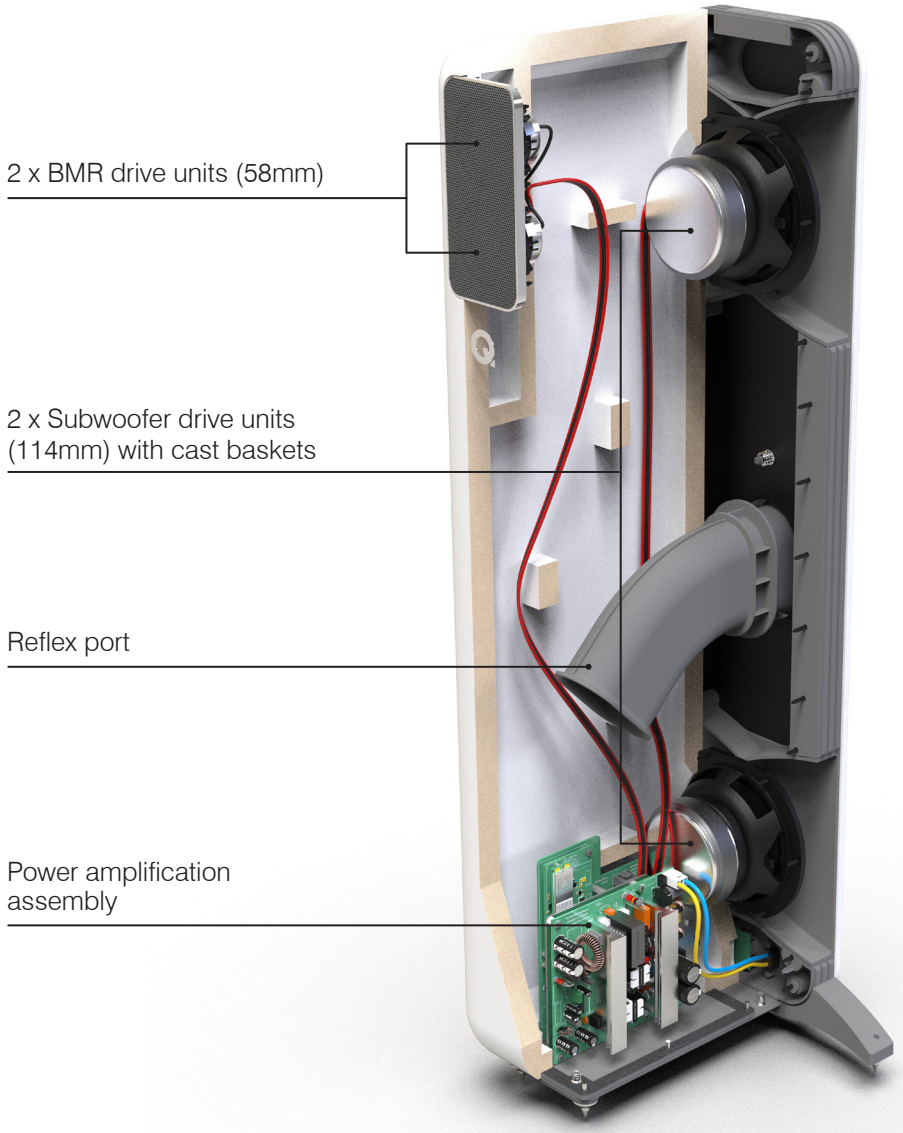


Figure 1: Q Active 400 detail

Component detail

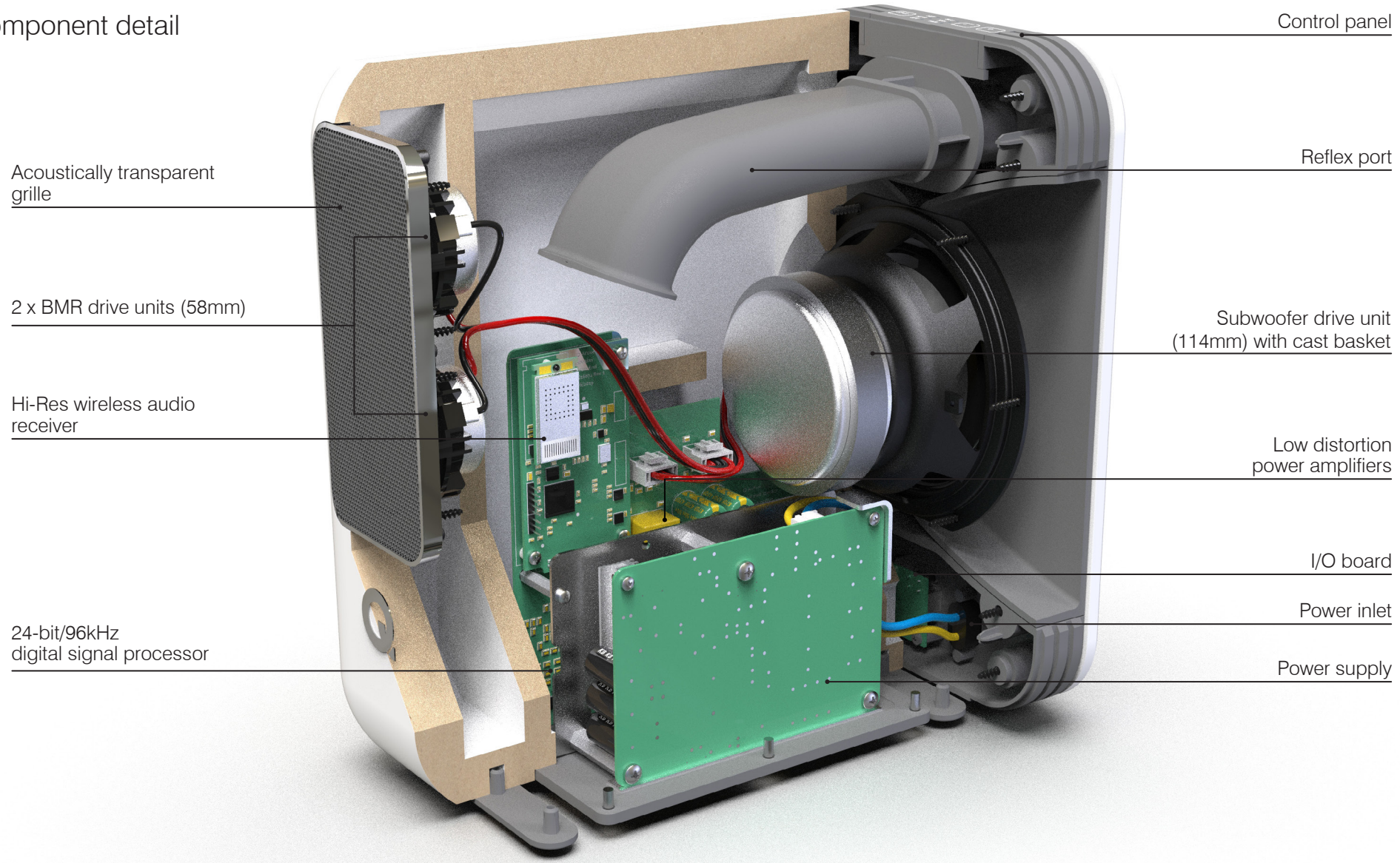


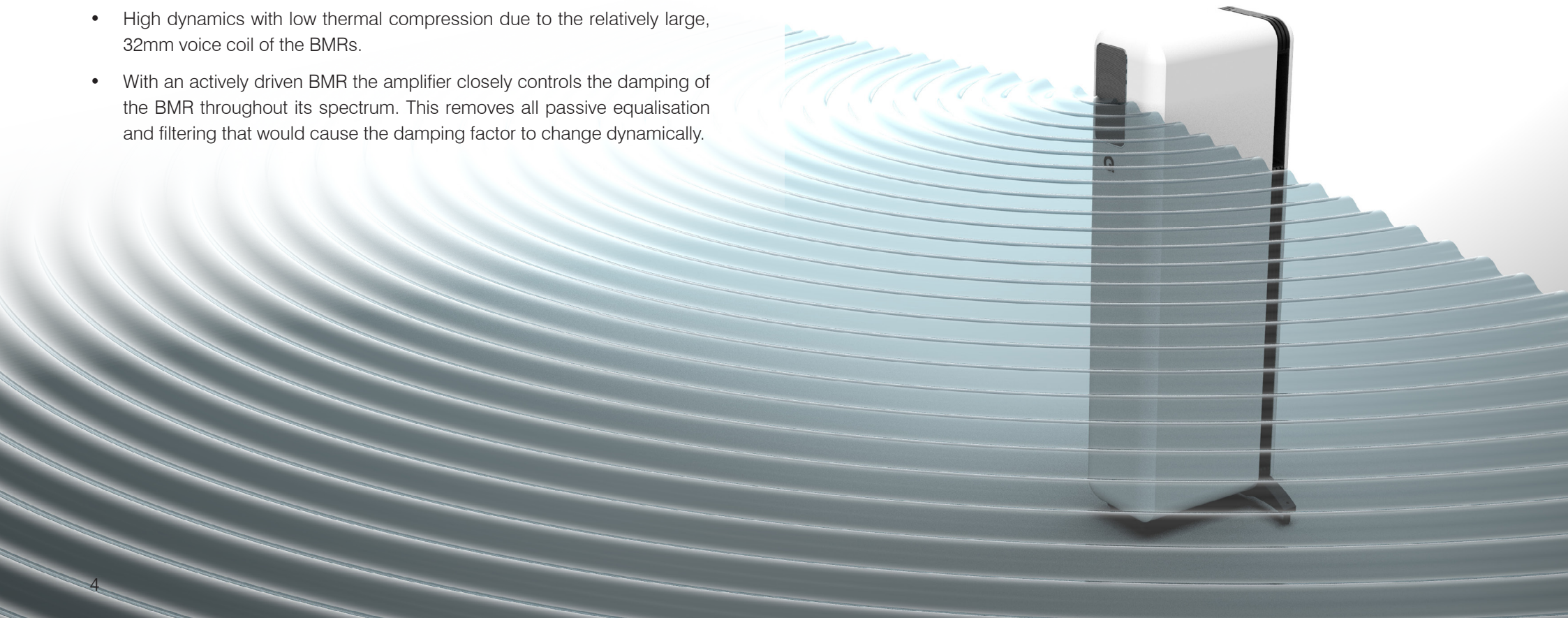
Figure 2: Q Active 200 detail

Balanced mode radiator (BMR) drivers

Why BMR?

At an early stage a BMR driver was reviewed as an alternative to a conventional dome tweeter as BMRs have a number of benefits useful to a system such as Q Active:

- Super wide dispersion for a panoramic sound stage.
- Seamless mid-range performance resulting in no mid-range crossover distortion.
- Extended lower frequency range to 150Hz for seamless integration with the inbuilt subwoofer.
- High dynamics with low thermal compression due to the relatively large, 32mm voice coil of the BMRs.
- With an actively driven BMR the amplifier closely controls the damping of the BMR throughout its spectrum. This removes all passive equalisation and filtering that would cause the damping factor to change dynamically.



Dual BMRs

To improve dynamics further and to maximise available sound pressure level (SPL), the speakers use a dual BMR system. Dual BMRs acoustically sum in a more sympathetic manner than conventional pistonic drive units.

In the case of Q Active, the designers have chosen to drive the BMRs with separate DSP and power amplifier channels. The DSP channel for the upper BMR runs down to the crossover point with the integrated subwoofer whereas the DSP channel for the lower BMR includes low-pass filtering set at a frequency of 5kHz. With this strategy, sound staging is not compromised as 'point source' behaviour is maintained for the speaker from the upper positioned BMR at high frequencies.

Asymmetrical positioning

The extended low frequency range of the BMRs enables the bass section to work in a region where its sound is not directional. The bass section can therefore be designed as an integrated subwoofer, built into the back of the cabinet. This creates a more stable, acoustically clean baffle on which to mount the BMRs.

Removing the bass driver(s) from the front of the cabinet frees up the designer to optimise the positioning of the BMR drivers. The asymmetric position chosen breaks symmetry in the acoustic path lengths from the BMRs to the baffle edges, improving diffraction and interference patterns on the baffle.

A secondary benefit of this asymmetric positioning lies in the channel switching for the speakers - each speaker can be set to reproduce the left or the right audio channel. This feature gives flexibility to position the BMRs toward the outside or inside to suit user preference, thus optimising the soundstage for the listener(s). As an example, for far-field listening the BMRs can be positioned to the inside, or for near-field listening the BMRs can be positioned to the outside (Figure 3).

Figure 3: Standmount speakers in near field listening position

Integrated subwoofer

Overview

The BMRs require only a slim cabinet section and modest internal volume to extend to 150Hz. This leaves a full 85% (standmount) and 95% (floorstander) of the cabinet volume to load the subwoofer drive unit(s).

The subwoofer drive units are substantial, high-power, long-throw bass units built in a 114mm die-cast chassis.

The standmount has a dedicated power amplifier that drives a single subwoofer built into a ported enclosure. The floorstander has two subwoofers with one positioned towards the top and one at the bottom of the cabinet. As with the standmount both subwoofers are driven by dedicated power amplifiers and the enclosure is a ported design.

One significant benefit of an active subwoofer design is that the amplifiers will drive a known load. They can therefore be optimised to work with the power handling and impedance of the drive units in the Q Active subwoofer.

Boundary control lens

Q Acoustics have implemented a boundary control lens in front of each subwoofer drive unit. This low frequency energy guide routes the airflow from the subwoofer drive units to the side vents of the cabinet. This strategy controls the boundary conditions for the subwoofer and ensures that the timing alignment between the subwoofer and BMRs is predictable.

The lens is mounted to a substantial, rigid brace that forms the back of the cabinet. Its form creates a controlled airflow (Figure 4) which would otherwise break up if the driver were facing a planar surface (Figure 5).

Time alignment

The Q Active includes time delay circuitry that digitally delays the signal reaching the BMRs, keeping the sound from the front mounted BMRs and the rear mounted subwoofer precisely time aligned.

Figure 4: Boundary control lens

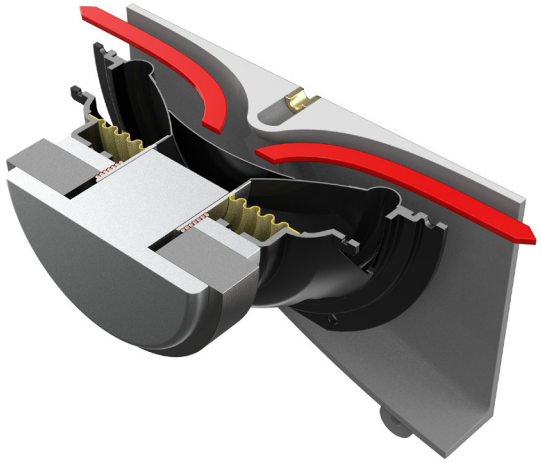
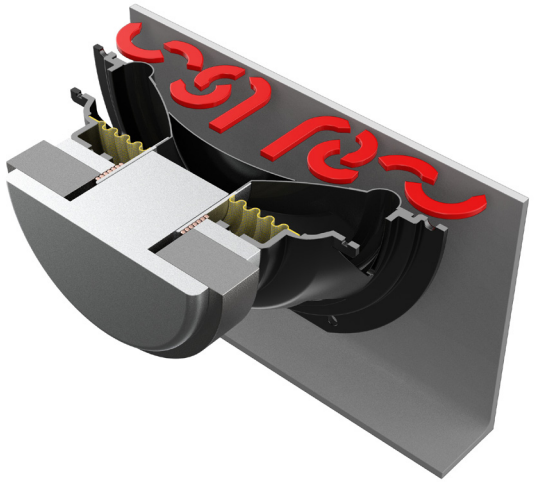


Figure 5: No boundary control lens



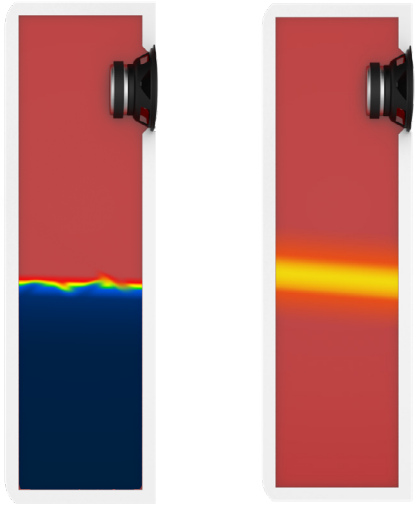
Balanced subwoofer drivers

Dual subwoofer drivers in the Q Active 400

A single drive unit mounted conventionally at the top of a floorstander cabinet creates a problem by efficiently exciting a standing wave in the speaker cabinet. This can be seen in the illustration Figure 6 which shows the ‘seesaw mode’ with one driver efficiently exciting the standing wave in the length of the cabinet at 210Hz. The nodal line can clearly be seen in both the pressure and phase.

To address this, the Q Active 400 subwoofer employs twin drive units driven in phase, one at the top of the floorstander and one at the bottom, effectively ‘locking’ the mode and resulting in uniform pressure throughout the enclosure volume. This can be seen in Figure 7, depicted by the absence of a nodal line and a constant phase within the enclosure.

Figure 6: Conventional driver configuration



Phase Pressure

Figure 7: Q Active 400 balanced driver configuration

Phase Pressure

Dart bracing

Dart bracing for the subwoofer drivers

A specific bracing formation in the form of an arrow dart is employed to good effect in both the standmount and floorstander cabinets. Figure 8 highlights this structure in red situated behind each of the subwoofer drive units.

Dart bracing provides high axial stiffness directly to the motor system, effectively providing a mechanical ground to the subwoofer drive unit(s). It gives superior mechanical stability to the drive unit over un-braced systems that can otherwise result in drive unit ‘bounce’ on the mounting fixtures and baffle.

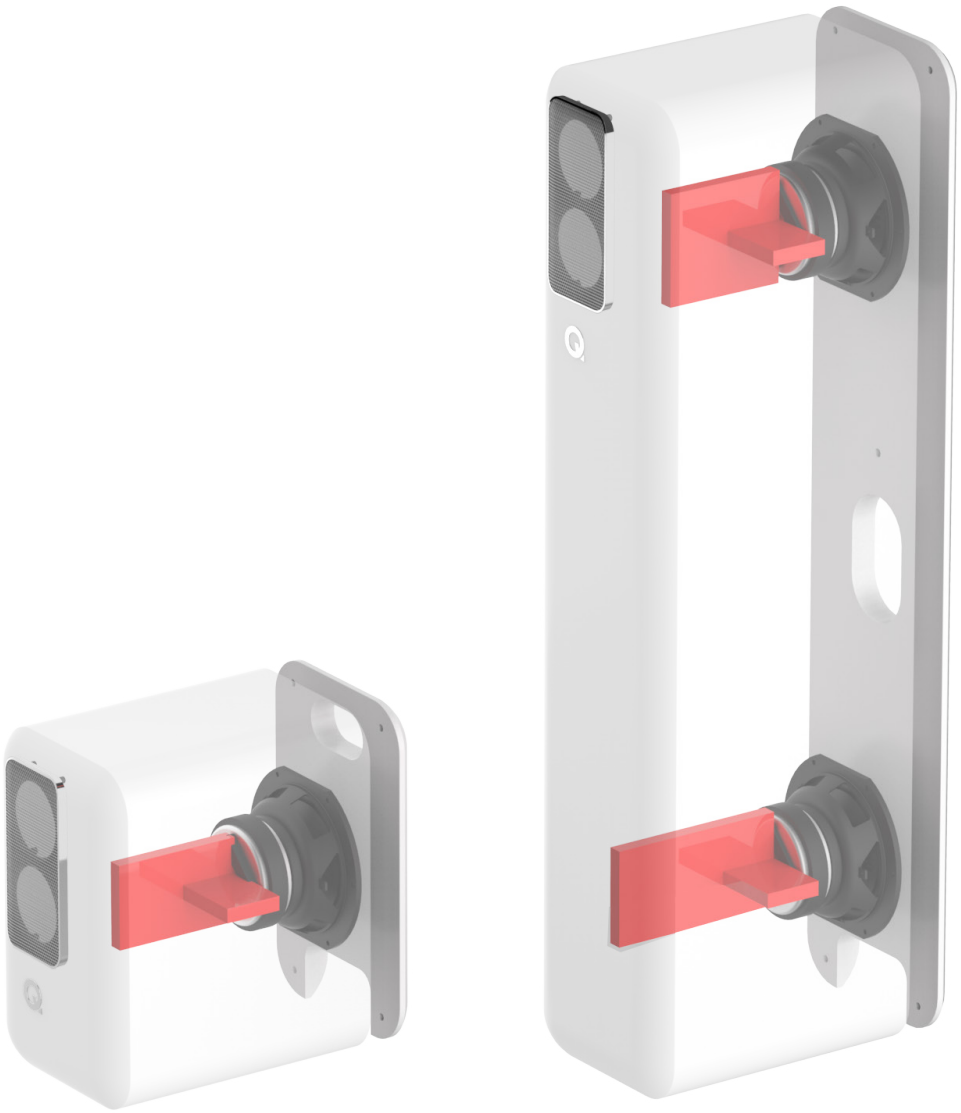


Figure 8: Dart braces

P2P bracing

Bracing the floorstander cabinet

Q Acoustics Point to Point (P2P) bracing is employed in the cabinet of the Q Active floorstander.

P2P bracing only supports the parts of the cabinet that need to be stiffened and does not spread unwanted energy randomly. The illustrations show how effective this methodology has become. A map of an un-braced floorstanding cabinet wall with respect to its deformation at a test frequency of 873Hz is shown in Figure 9. Where velocity 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. A hot spot of vibration has been created at the test frequency. 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 test is repeated on the treated enclosure, the deformation map shows how effectively the cabinet resonances have been reduced. In figure 10 the lower surface displacement of the P2P can clearly be seen. Note that a like for like scaling factor has been applied to the images for illustration purposes.

Figure 9: Cabinet without P2P - high resonance

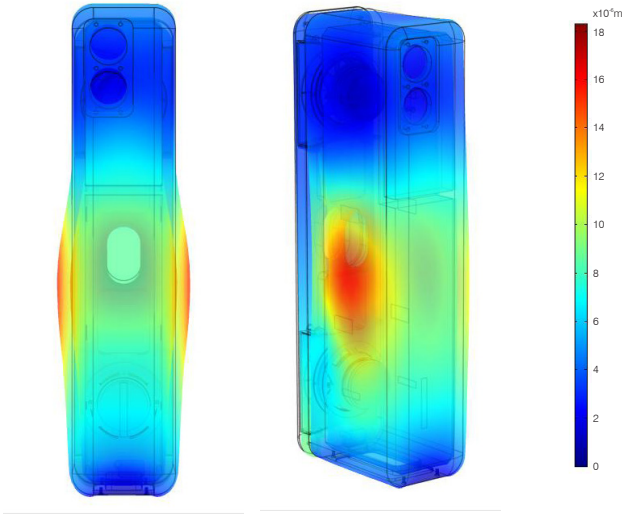
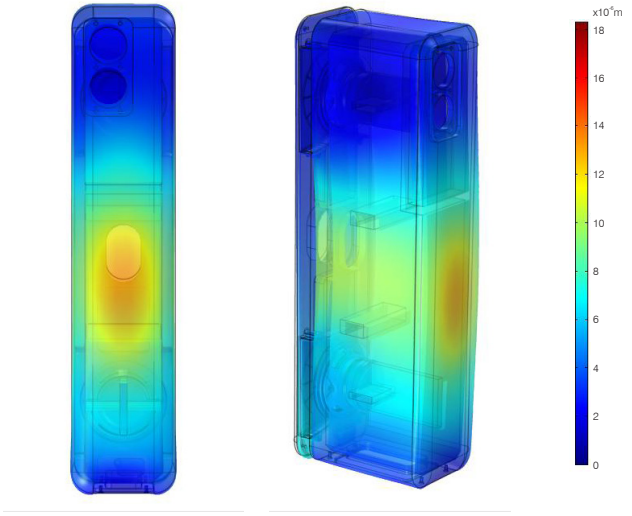


Figure 10: Cabinet with P2P - low resonance



Q Active stand

Designed for Q Active 200

The Q Active stand (Q FS75) has been designed specifically to partner with the standmount speaker, providing a stable mounting platform for the speaker with low resonance and minimal reflective surfaces.

The base of the standmount speaker includes fixings to enable the Q Active Stand to be bolted rigidly to the speaker.

Inspired by tensegrity

The striking design of the Q Active speaker stand adopts the principles of a space frame consisting of rods in compression stabilised by cables in tension.

Important benefits of this arrangement lie in the skeletal, high rigidity construction that has minimal parallel or planar surfaces.

Minimising reflections

A known problem with conventional speaker stands is that their relatively large surface area acts as a re-radiating surface for the sound waves created by the drivers above them. Sound leaving the drive units will radiate uniformly in all directions and will reflect from any nearby surfaces - such as the speaker stand - with an accompanying phase shift causing constructive and destructive interference with the direct sound.

Finite element analysis has shown how a real-world radiated sound field is affected by reflections from the surface of the different types of stand.

In the diagrams, traditional solid and steel column stands are compared to a Q Acoustics space frame design. The radiated sound field should look like perfect ripples on a still pond after a stone is thrown into the water. As can be seen, the solid MDF (Figure 11) and column (Figure 12) designs re-radiate far more of the original loudspeaker signal and therefore contribute significant disturbance (red and yellow) to the ideal sound field when compared with the space frame design (Figure 13).

Figure 11: Solid MDF stand

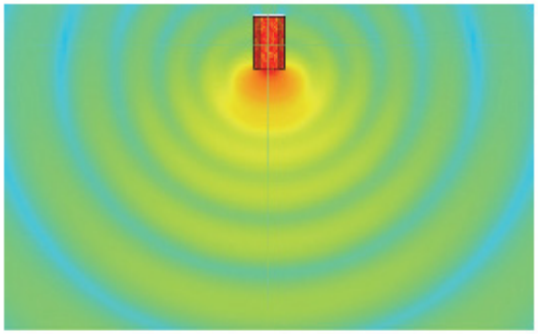


Figure 12: Tubular steel stand

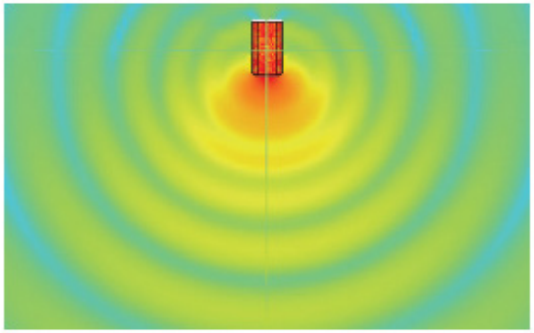
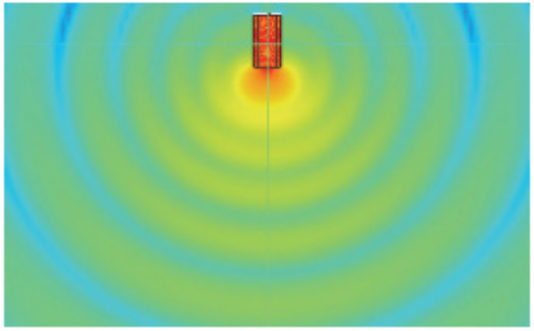


Figure 13: Space frame stand



The Q Active system

A complete audio system

Q Active is far more than ‘just’ a pair of high quality loudspeakers. It is a complete audio system. With minimal intrusion into any living space, there is no requirement for separate amplification, sources, interconnects or cables.

Hub

The compact hub is a key component in the system, combining the functions of a preamplifier and music streaming source.

It includes wired or wireless connection to a local network for streaming, wired inputs for HDMI (ARC), digital audio and an analogue input that is switchable between line level or moving magnet (MM) input for a turntable.

A 5GHz digital wireless link transfers the left and right channel audio from the hub to the speakers.

System control

In use, the system is completely flexible for a user to control in whichever way is most convenient. The system integrates seamlessly with apps when streaming or playing *Bluetooth* audio and with TV remote controls via HDMI (ARC). A dedicated Q Active remote control is also provided for legacy sources.

There is no requirement to install a Q Active app to control these speakers.

System connectivity

Music streaming

The Q Active hub includes network streaming and requires no special mobile app for this. Any app that features compatibility with these technologies will stream to the Q Active system.

Connecting a TV

The hub features HDMI audio return channel (ARC) connection with consumer electronics control (CEC).

Connect the hub to an HDMI (ARC) outlet on a compatible TV to route 2 channel TV sound through the Q Active system.

If the TV also features CEC, the TV remote can take control of essential functions of the Q Active system such as standby and volume control.

Analogue and digital sources

The hub includes connectivity for wired sources including an analogue input (switchable between line level and phono MM).

A Toslink digital input enables connection to a digital audio source such as a CD or DVD player or a TV.

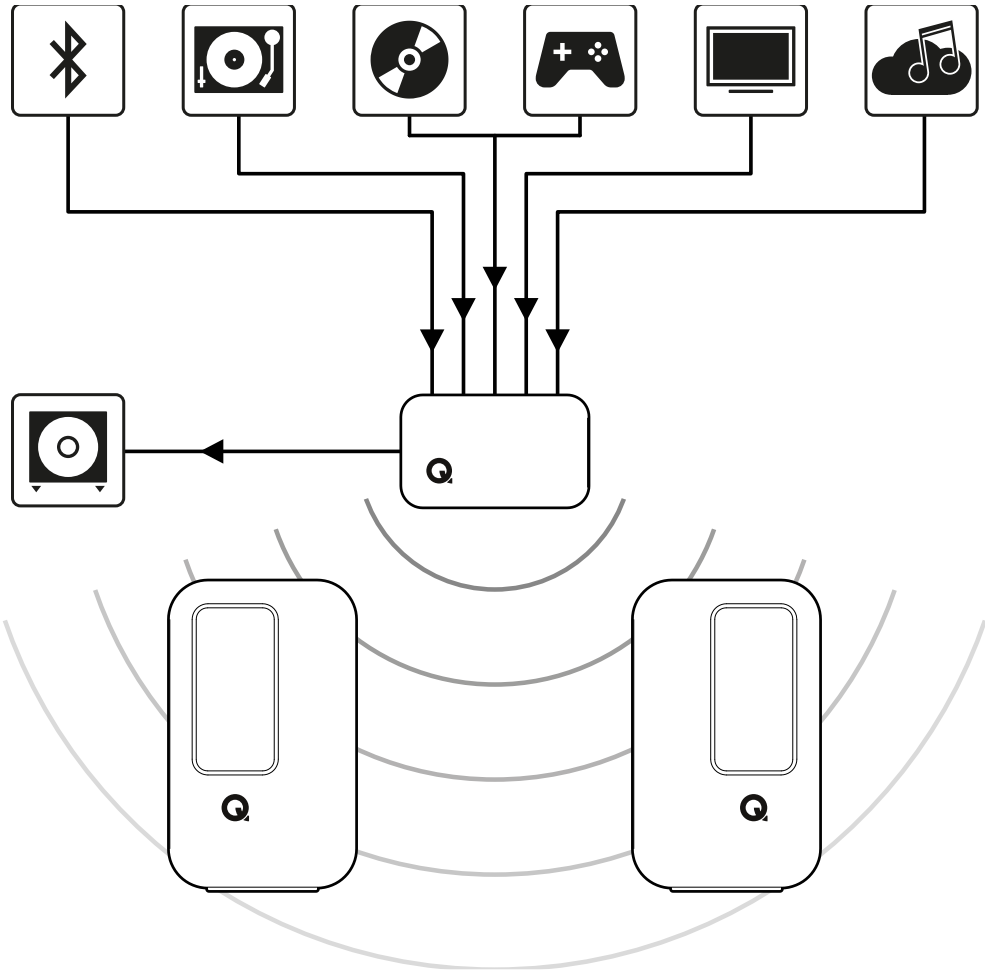
Bluetooth

Bluetooth audio is included for universal wireless connectivity.

Sub out

Sub out is an optional feed to connect a separate subwoofer to the system. This output is a second order low pass-filter set to -6dB @ 450Hz. A connected subwoofer may be set to extend the response of the system to include low frequency sound effect information for home cinema or just to reinforce bass response in very large spaces.

Figure 14: System connectivity diagram



Streaming

Overview

Q Active is capable of streaming music or radio from a wide variety of providers using the different connectivity methods described below. The user can use any app which supports one of the listed methods, or alternatively use voice control via compatible smart speakers or mobile devices.

Connectivity methods

All Q Active systems include these connectivity methods:

- AirPlay 2
- Spotify Connect
- Roon ready
- UPnP™*
- *Bluetooth*

Q Active is available in two different versions making it compatible with either:

1. Google Home system
    - Chromecast built-in™
    - Google Home assist voice control
2. Alexa system
    - Works with Alexa

*Both versions of Q Active can be used with many Universal Plug and Play (UPnP) servers and control apps. The Q Active system will appear as a selectable speaker system on the UPnP control app. Many Network Attached Storage (NAS) drives are supplied with UPnP server software, and can provide a library of compatible digital music files which can be played through Q Active.

Using voice control

The 'Chromecast built-in' version integrates with other 'Google Home' compatible devices. Voice commands to any Google smart speaker or setup via the Google Home app will control the playback selection and volume on the Q Active system.

Similarly, the 'Works with Alexa' version forms part of an Amazon ecosphere with other compatible devices. Voice commands to an Echo device or via the Alexa app will control the playback selection and volume on the Q Active system.

All Q Active systems can be operated using Siri voice control once the speakers have been added to the Apple Home App. Voice commands can then be made via any Siri enabled hardware, or using a compatible iPhone or iPad to control the playback and volume of Q Active.

Multi-room

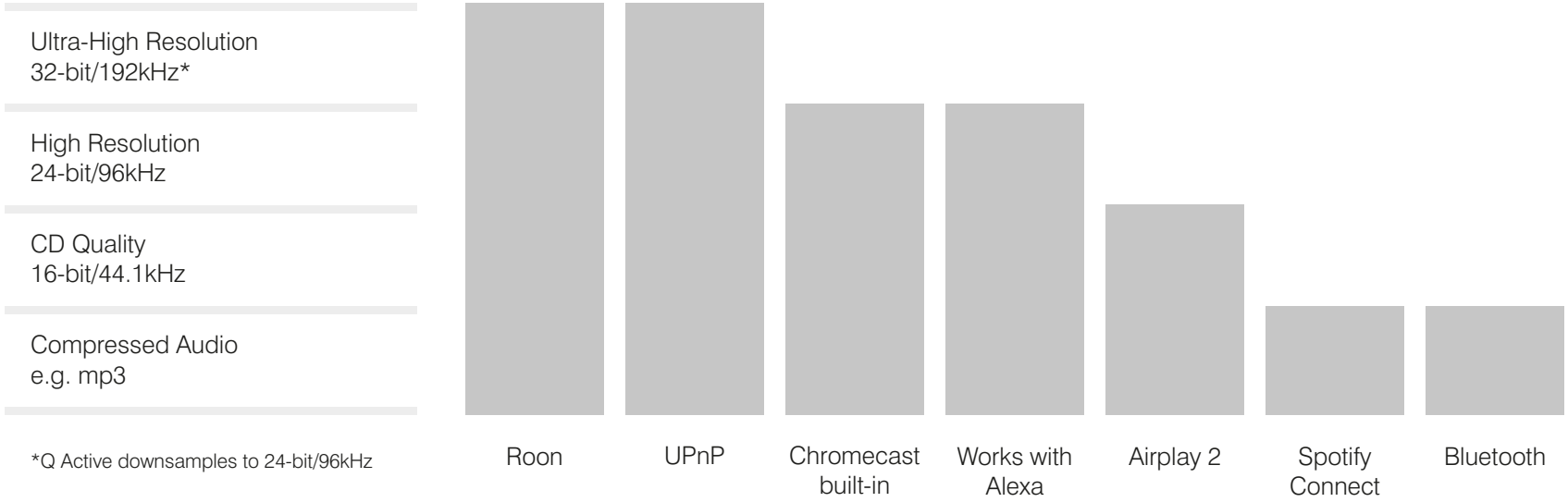
Q Active can form part of a multi-room speaker group using the following connectivity methods:

- AirPlay 2
- Roon ready
- Chromecast built-in
- Amazon multi-room music

Resolution comparison charts

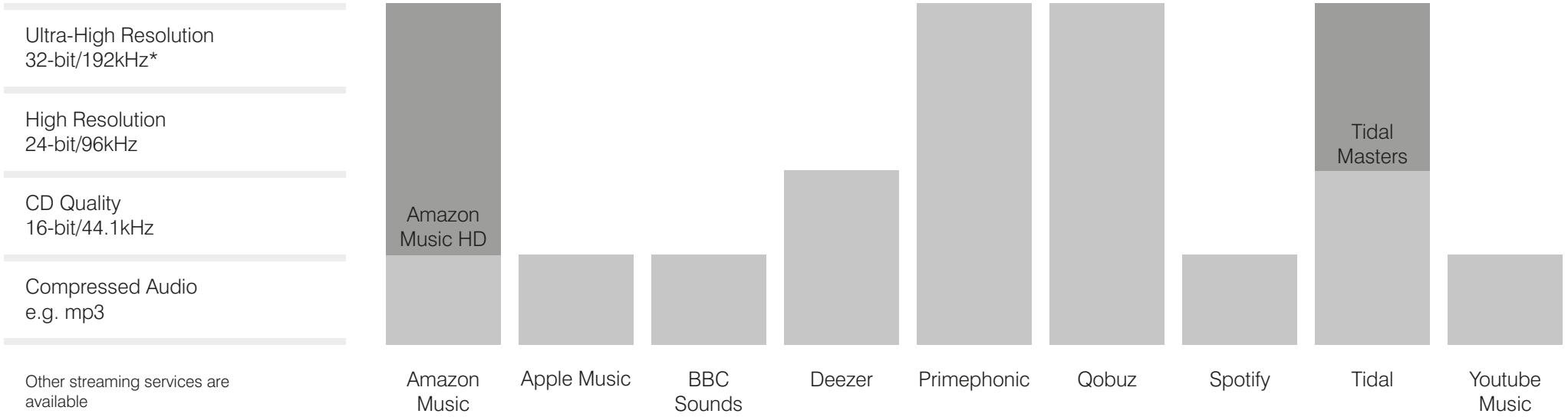
The charts opposite show a graphical comparison of the connectivity methods supported by Q Active and the most popular streaming services available (figures correct at time of print).

Connectivity methods comparison



*Q Active downsamples to 24-bit/96kHz

Streaming services comparison



Other streaming services are available

The hub in detail

Optical and HDMI inputs

Digital audio from the optical and HDMI inputs is routed through the sample rate converter (SRC) and re-sampled to 24-bit/96kHz, regardless of native bit depth and sample rate.

Sample rate converter

A key element in the hub topology is the SRC. This accepts the signals from the digital and HDMI wired sources and converts any incoming audio signal to 24-bit/96kHz digital audio. The 96kHz sample rate ensures that any aliasing due to the sampling process is shifted up in frequency and well away from the audio band.

Analogue inputs

The analogue input is switchable to match either a turntable with moving magnet cartridge or a line input. Analogue inputs are routed through a 24-bit analogue to digital converter (ADC) that runs at a sample rate of 96kHz to also minimise aliasing.

Clock strategy

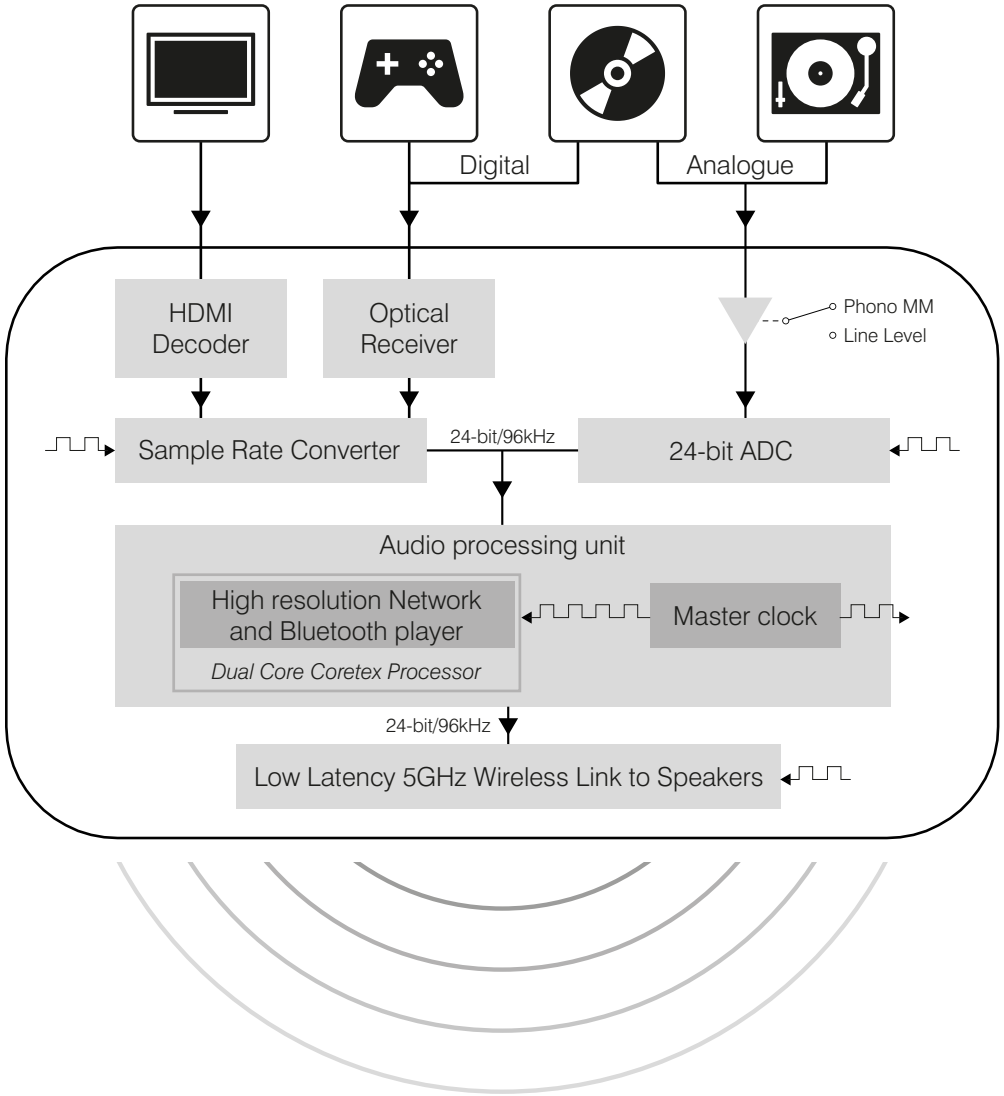
Jitter in digital signals causes dynamic time domain distortions that are not harmonic in nature. Although difficult to measure precisely in an audio signal, jitter artefacts can be quite audible when listening to a digital audio system.

To address this, the hub includes a single, low jitter ‘master’ clock in the circuit responsible for receiving streamed and *Bluetooth* audio. This reference clock is also used to time the re-sampled data out from the SRC, effectively minimising jitter that could otherwise have been present in a clock recovered from the input signal.

Low latency 5GHz link to speakers

The hub connects wirelessly to the speakers over a dedicated 5GHz digital link. This is designed with super-low latency to ensure left and right channels stay precisely in step for a stable stereo image.

Figure 15: Hub detail diagram



Configuration

Overview

Q Active is a highly flexible system that can be optimised for both the room environment and the listener's system needs.

Channel setting

A channel setting switch on the back of each speaker enables it to be set to the left or right channel. This, with the asymmetrical design of the speakers allows the BMR drive units to be positioned optimally for near-field or far-field listening.

Boundary setting

A 3-position boundary setting switch on each speaker enables the DSP to change the speaker's voicing. Consequently Q Active speakers may be optimised for a number of different listening environments including:

- Positioned close to a corner.
- Positioned close to a wall.
- Free-space.

Conclusion

Meeting the design brief

Q Active speakers are the fusion of refined, innovative acoustic and industrial design, with modern connectivity in a compact and powerful package.

Acoustically, the Q Active speakers embody many new and interesting design ideas:

- BMR and integrated subwoofer driver configuration.
- Separate DSP and power amplification for each individual driver.
- Precision braced cabinet design including an asymmetrical front baffle and boundary control lens.

The acoustic design is integrated into a system that offers expertly considered components:

- Wired HDMI, optical and analogue or phono connectivity to a separate hub.
- High resolution 24-bit/96kHz wireless connection from the hub to the speakers.
- Streaming via Chromecast built-in, Amazon Alexa and Apple Airplay 2 for smart home integration.

All these elements allow the user to create immersive hi-fi sound without any intrusion of traditional audio component stacks and wiring. A thoughtful approach to the entire system design has culminated in an experience that combines traditional audio and the future of enjoying music in the home.

Q Active has been developed from an idea to a finished product by a creative and great group of people that make up the Q Acoustics team and we would like to thank all those who have contributed.

Specification

Product	Q Active 200	Q Active 400	Hub
Acoustics			
Enclosure type	Reflex (ported)	Reflex (ported)	-
Full range driver	2 x BMR 58mm (2.25in)	2 x BMR 58mm (2.25in)	-
Subwoofer (high excursion)	1 x 114mm (4.5in)	2 x 114mm (4.5in)	-
Crossover frequency	150Hz	TBC	-
System frequency response (free boundary)	46Hz to 20kHz (-6dB)	TBC	-
Power (per speaker)			
Continuous power	100W	TBC	-
Peak power	280W	TBC	-
Power requirement			
Voltage range	100 - 240 VAC, 50/60 Hz	100 - 240 VAC, 50/60Hz	100 - 240 VAC, 50/60Hz
Weight and dimensions			
Un-boxed weight (per speaker)	7.5kg	17.5kg	0.5kg
Dimensions (per speaker) H x W x D	284 x 170 x 290mm (11.2 x 6.7 x 11.4in)	825 x 320 x 290mm (32.5 x 12.6 x 11.4in)incl. spikes & stabiliser	40 x 180 x 112mm (1.6 x 7.1 x 4.4in)
Dimensions on stand H x W x D	922 x 286 x 338mm (36.3 x 11.3 x 13.3in)	-	-
Wireless connectivity			
Bluetooth	-	-	v4.1 Low Energy
Wi-Fi	-	-	IEEE 802.11 a/b/g/n and 802.11ac compliant
Hi-Res Wireless Link frequency	5.8GHz	5.8GHz	5.8GHz
Remote control	-	-	2.4GHz
Audio playback			
Codec formats	-	-	AAC, WAV, FLAC, MP3, Vorbis, WMA & ALAC
Sample frequency	96kHz	96kHz	8 – 192kHz (depending on codec)
Bit depth	24bits	24bits	8 – 32bits (depending on codec)
Wired connectivity			
Digital optical	-	-	96kHz/24bit Toslink
Digital HDMI	-	-	96kHz/16bit ARC (2 channel)
Analogue (set to line level)	-	-	300mV/18kΩ
Analogue (set to phono MM)	-	-	2.6mV/47kΩ (RIAA Equalised)
Subwoofer output	-	-	1.20V (0-300Hz)

ACOUSTICS

Our policy is one of continuous product improvement.
We reserve the right to change the designs and specifications without notice.

Issue 5