Application Note
January 2015

Tweeter Resonator Attachment for Earphone Design and Prototyping

Knowles balanced armature Tweeters are commonly used to enhance high frequency response for music earphones. To optimize performance, a designer must consider both component selection and acoustic path. This note describes a resonator structure intended to simplify hybrid and multiple balanced armature earphone prototyping.

Background

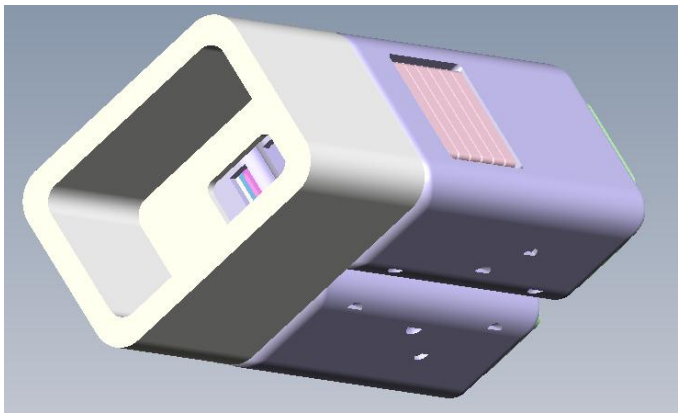
The high frequency extension provided by a tweeter in an earphone depends on both the mechanical resonance of the tweeter component and the acoustic resonance determined by the acoustic path from the tweeter to the earphone exit. Normally, when designing an earphone, some iteration of acoustic modeling and prototyping are needed to optimize the tweeter response.

To simplify design and prototyping, we offer two examples of resonator extensions that can be easily attached to tweeters to provide a path with known and optimized performance. The resonators are appropriate for designs where the exit of the resonator path can coincide with the end of the exit tube of the earphone. In other words, the tweeter component must be placed within the exit tube of the earphone to realize the performance presented in this note.

Two resonators are presented. One is compatible with a tubeless FK-sized dual tweeter (DFK, DWFK, or SWFK series). The other is compatible with a single FK-sized single tweeter with port tube (FK or WBFK). The structures and acoustic performance are presented, and CAD files of the resonators can be made available to earphone designers for 3D printing and inclusion in prototype earphone designs.

Resonator for Dual Tweeter

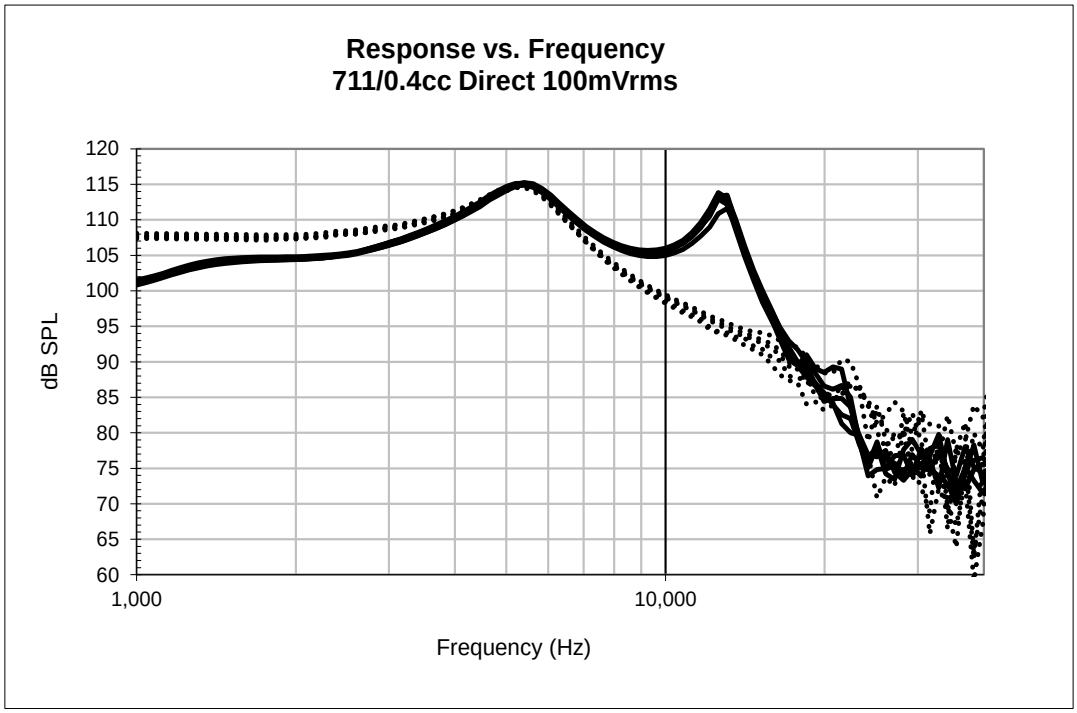
A resonator to fit a dual tweeter was designed, 3D printed and measured to assess performance. The initial 3D part design includes a space for mounting an acoustic damper but the recommended configuration is un-damped. The 3D part pictured fits tubeless dual FK series tweeters. We have designs for both tubed and tubeless duals. A tubeless version of SWFK-31736-000 was used for prototyping. Epoxy is used to cement the 3D printed part to the SWFK.



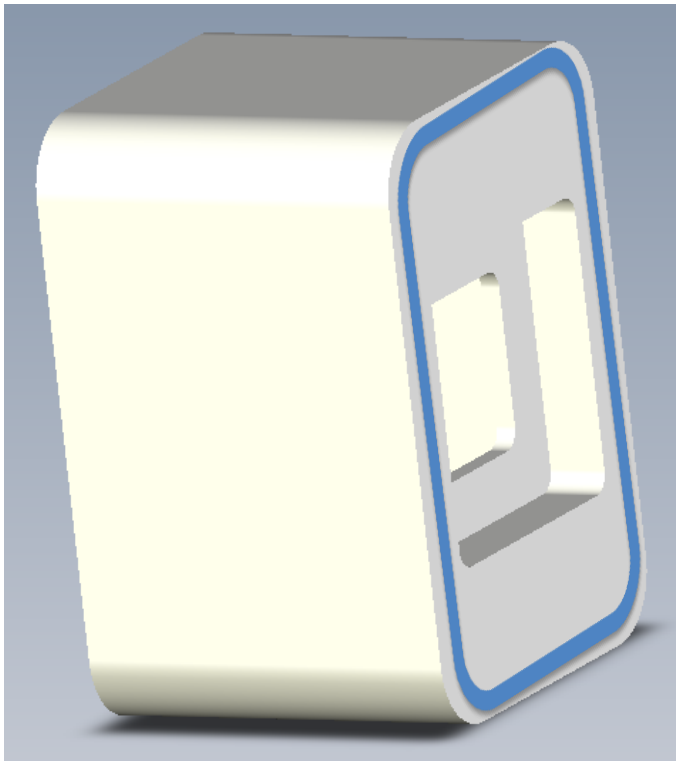
Resonator attached to tubeless SWFK (8mm x3.9mm x 2.7mm)

The dual resonator assembly was measured directly into two couplers for frequency response:
IEC 60318-4 "711"
GRAS 43BA-2 (0.4cc)

Frequency response: SWFK + 3D printed resonator



Solid line is 711, Dotted line is 0.4cc. Response is shown to 40kHz. The 13kHz peak in 711 response is the coupler resonance. 0.4cc coupler resonance is higher in frequency and shows a more accurate response in the treble range.

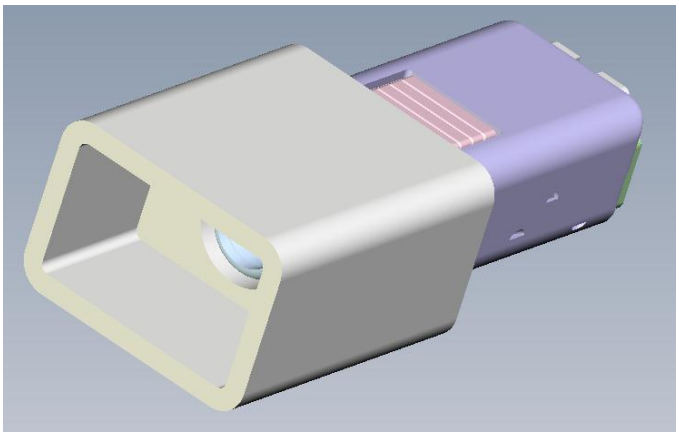


Left: Location for bead of epoxy applied to resonator for attach to SWFK w/o tube. Cement must create an airtight seal.

Below: SWFK with resonator pictured with “Seashell” demonstrator earphone. A larger exit tube OD is needed to fit the tweeter assembly and allow path for woofer sound exit.

Resonator for Single Tweeter

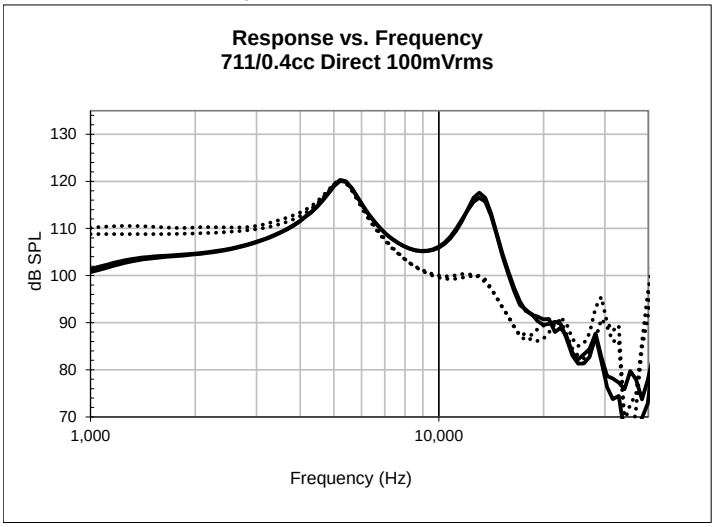
A similar resonator was designed to fit a single tweeter. The single resonator assembly fits FK or WBFK tweeter components. The cavity dimensions for the single resonator matches the cavity dimensions for the dual resonator. However the single resonator does not include a mounting surface for a damping screen. The single resonator is intended to fit FK or WBFK components with port tube included. The port tube helps locate the resonator for cementing.

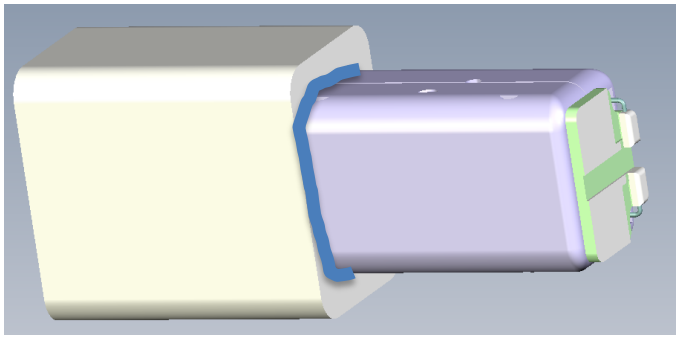


Resonator attached to WBFK-32203-000 (8.5mm x3.9mm x 2.7mm)

The single resonator assembly also measured directly into two couplers for frequency response:
IEC 60318-4 "711"
GRAS 43BA-2 (0.4cc)

Frequency response: WBFK + 3D printed resonator





Cementing location along seam between WBFK and single resonator. Cement must create an airtight seal at the seam.

WBFK with resonator pictured with “Seashell” demonstrator earphone. A larger exit tube OD is needed to fit the tweeter assembly and allow path for woofer sound exit.

Application Considerations

The tweeter/resonator assemblies are intended to assist the designer with both prototyping and sound path design. We assume that the earphone design will be either hybrid (dynamic woofer + BA tweeter) or BA multi-way. The tweeter/resonator assembly can be installed in a prototype earphone and provide known high-frequency response extension. Alternately, the acoustic geometry of the resonator could be duplicated in the customer's housing design (prototype or hard tooled), again providing known high frequency performance.

With the high-frequency response shape understood, the designer may then focus on achieving the desired overall response shape, woofer tweeter output balance, and cross-over -- speeding the development process.