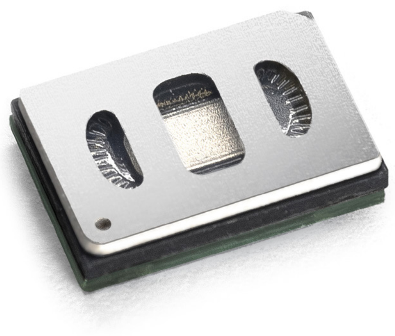
MEMS SPEAKERS

ADAP UT-P2023 | DATASHEET

U))) SOUND



Adap UT-P2023 is a MEMS speaker that is ideal for free-field audio solutions such as wearables. With a thin form factor of 1.6 mm, it enables the maximum design flexibility of ergonomic devices. Adap UT-P2023 MEMS speakers provide natural and precise audio output up to 20 kHz.

FEATURES

- Audio range bandwidth
  - free-field (2 kHz – 20 kHz)
  - occluded-ear (20 Hz – 20 kHz)
- Competitive sound pressure level
- Thin form factor 6.7 x 4.7 x 1.58 mm
- No magnetic field; eliminating electromagnetic interference (EMI)
- Low heat generation
- Automated manufacturing process

APPLICATIONS

Adap UT-P2023 speakers are suitable for free-field audio systems such as wearables and AR/VR glasses, and in-ear applications such TWS headphones. For 2-way earphones, Adap UT-P2023 speakers can be used as tweeters.

Adap UT-P2023 | Datasheet
Released in February 2021 | Updated in July 2023
USound GmbH | www.usound.com | sales@usound.com

U))SOUND

CONTENT

REVISION HISTORY

February 2021: Release
May 2021: Capacity value changed, page 3; speaker gasket information added, page 13
July 2023: Updated Acoustic Performance section, pages 8-12

SPECIFICATIONS

General acoustics			
f_{res}	[kHz]	2.9	±10%
Q-factor	[-]	0.7	
Effective membrane surface – S_D	[mm²]	12	
Equivalent volume – V_{AS}	[mm³]	40	
Front volume inside speaker	[mm³]	5.6	
Back volume inside speaker	[mm³]	20	

Acoustics in baffle (IEC 60268-5)			
SPL @ 1 kHz / 10.6 V_{RMS} (15 V_P) + 15 V_{DC}	[dB]	53	±3.0
SPL @ 4 kHz / 10.6 V_{RMS} (15 V_P) + 15 V_{DC}	[dB]	71	±3.0
SPL @ 10 kHz / 10.6 V_{RMS} (15 V_P) + 15 V_{DC}	[dB]	76	±3.0
SPL @ 1 kHz / 3.5 V_{RMS} (5 V_P) + 15 V_{DC}	[dB]	43	±3.0
SPL @ 4 kHz / 3.5 V_{RMS} (5 V_P) + 15 V_{DC}	[dB]	60	±3.0
SPL @ 10 kHz / 3.5 V_{RMS} (5 V_P) + 15 V_{DC}	[dB]	65	±3.0
THD @ 1 kHz / 3.5 V_{RMS} (5 V_P) + 15 V_{DC}	[%]	16	+8
THD @ 4 kHz / 3.5 V_{RMS} (5 V_P) + 15 V_{DC}	[%]	5	+3
THD @ 10 kHz / 3.5 V_{RMS} (5 V_P) + 15 V_{DC}	[%]	4	+3
Acoustics in coupler (IEC 60318-4)			
SPL @ 1 kHz / 10.6 V_{RMS} (15 V_P) + 15 V_{DC}	[dB]	117	±3.0
SPL @ 2 kHz / 10.6 V_{RMS} (15 V_P) + 15 V_{DC}	[dB]	120	±3.0
SPL @ 5 kHz / 10.6 V_{RMS} (15 V_P) + 15 V_{DC}	[dB]	118	±3.0
THD @ 1 kHz / 3.5 V_{RMS} (5 V_P) + 15 V_{DC}	[dB]	1.4	+0.3

Electronics			
Capacitance	[nF]	26	±5

Operating conditions		
Maximum AC voltage (peak) – up to 20 kHz	[V_P]	15
Maximum DC voltage	[V]	15

Mechanics		
Size	[mm]	6.7 x 4.7 x 1.58
Total speaker weight	[mg]	80
Total speaker cubic volume	[mm³]	50

MECHANICAL DIMENSIONS

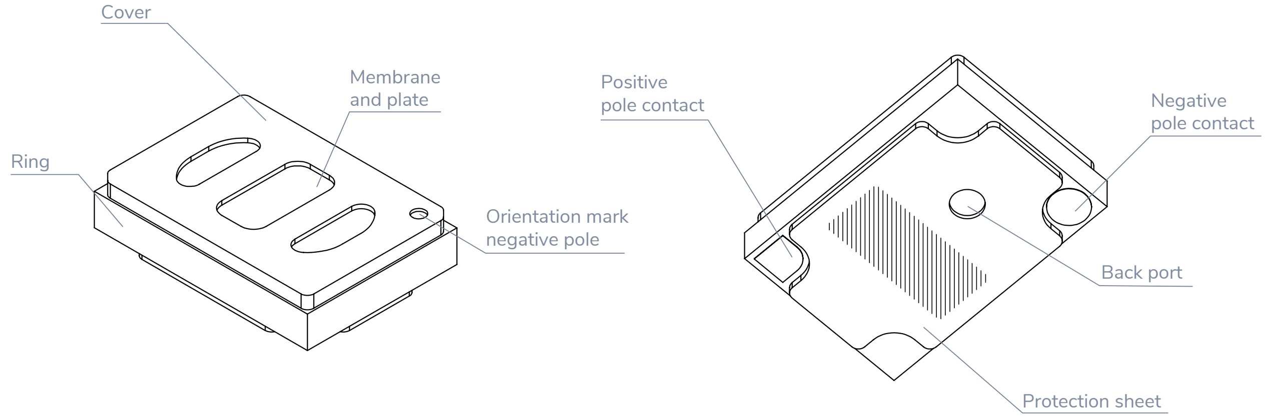


Figure 1: Speaker perspective view.

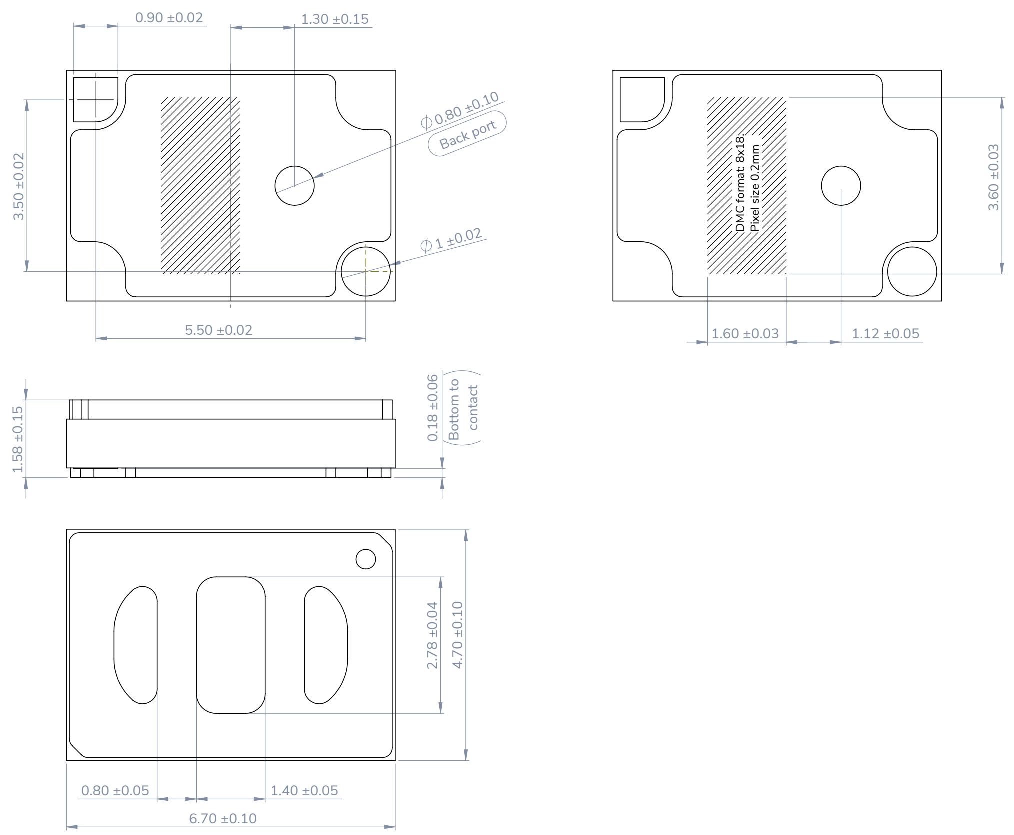


Figure 2: Speaker bottom/side/top views. Dimensions in mm.

FORCE ON SPEAKER

Type of stress	Maximum handling force [N]	Maximum permanent force [N]
Front face compression	20	13
Side face compression	20	13
3 point bending	10	5
Force on membrane	0	0

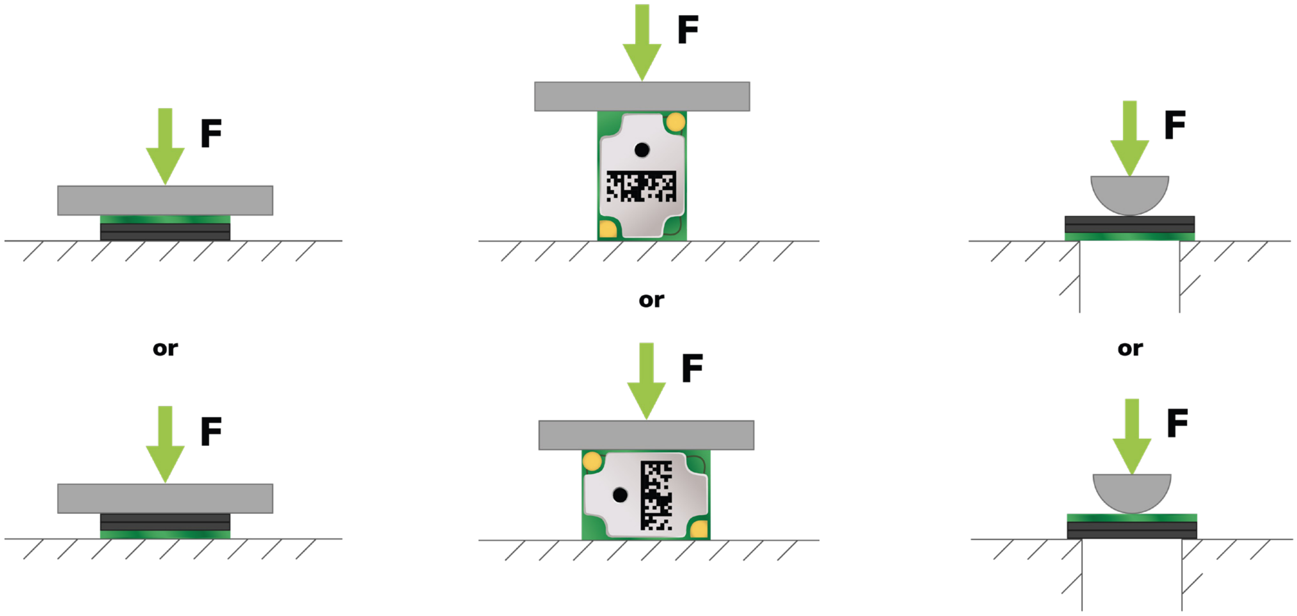


Figure 3: **Left: front face compression, centre: side face compression, right: 3-point bending.**

TEST CONDITIONS

General	
Measurement system	Audio Precision APx
Measurement signal	Exp. Sweep
Voltage level V_{AC} + V_{DC}	10.6 V_{RMS} (15 V_P) + 15 V_{DC}
Applied back volume	Open (infinite)

Baffle	
Baffle type	IEC 60268-5
Mic distance	3 cm
Reference distance	10 cm
Microphone diameter	1/2”
Microphone	GRAS 46AC

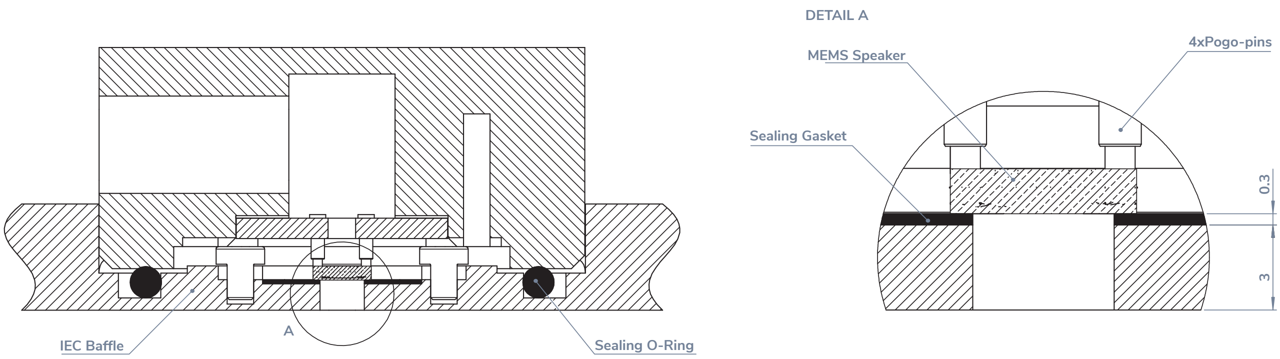


Figure 4: **Baffle cross-section. The outlet through the baffle for the speaker has the same shape as the inside of the speaker cover.**

Usound offers a speaker evaluation kit (Carme kit UJ-E1040G00) to measure the speakers performance in the baffle easily. See “Acoustic performance using Carme kit UJ-E1040G00” section. The coupler adapter from Carme kit UJ-E1040G00 should be used to obtain the same results (coupler measurements) as in the datasheet.

REFERENCE DRIVING CIRCUIT

In Figure 5 and Figure 6 the reference driving circuit is shown. It includes the amplifier TI LM48580 and the DC boost converter TPS61046.

The boost converter is configured to provide a constant 15 V_{DC} offset for the speaker. The amplifier circuit itself is based on the typical application diagram from the LM48580 datasheet. It is based on a single-ended input signal but can also be modified according to the datasheet to a differential input.

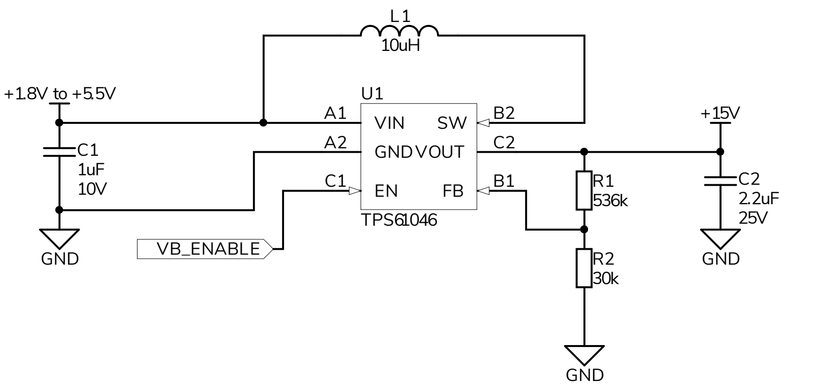


Figure 5: **TPS61046 boost converter including required passive components.**

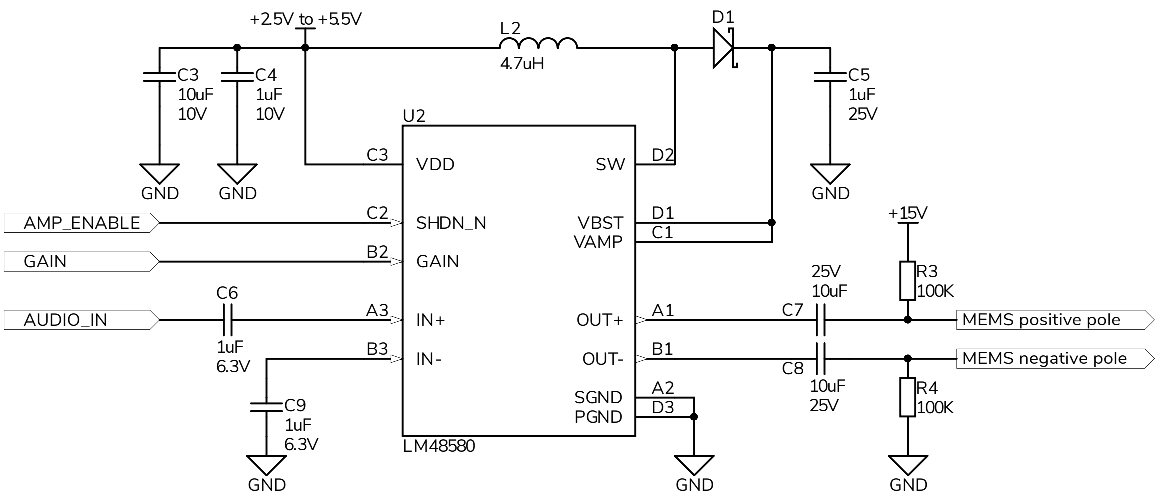


Figure 6: **LM48580 amplifier, including required passive components.**

ACOUSTIC PERFORMANCE

ACOUSTIC PERFORMANCE IN BAFFLE

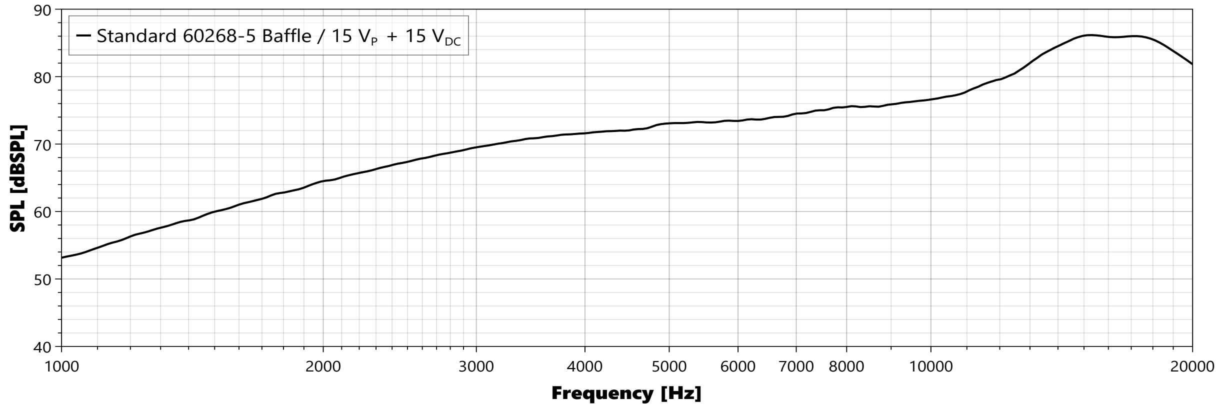


Figure 7: **SPL at 15 V_P + 15 V_{DC} drive, measured with the standard Baffle (IEC 60268-5).**

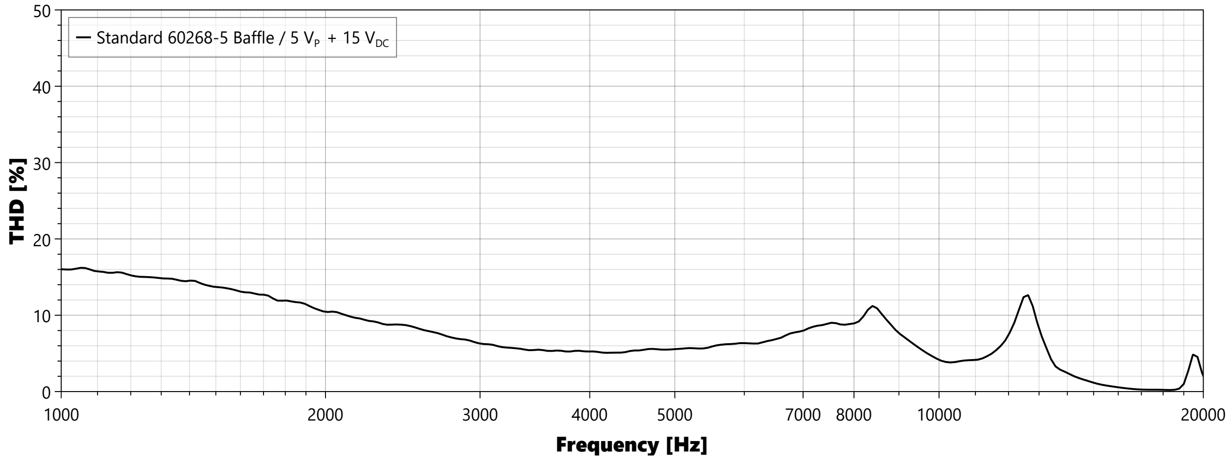


Figure 8: **THD at 5 V_P + 15 VD_C drive, measured with the standard Baffle (IEC 60268-5).**

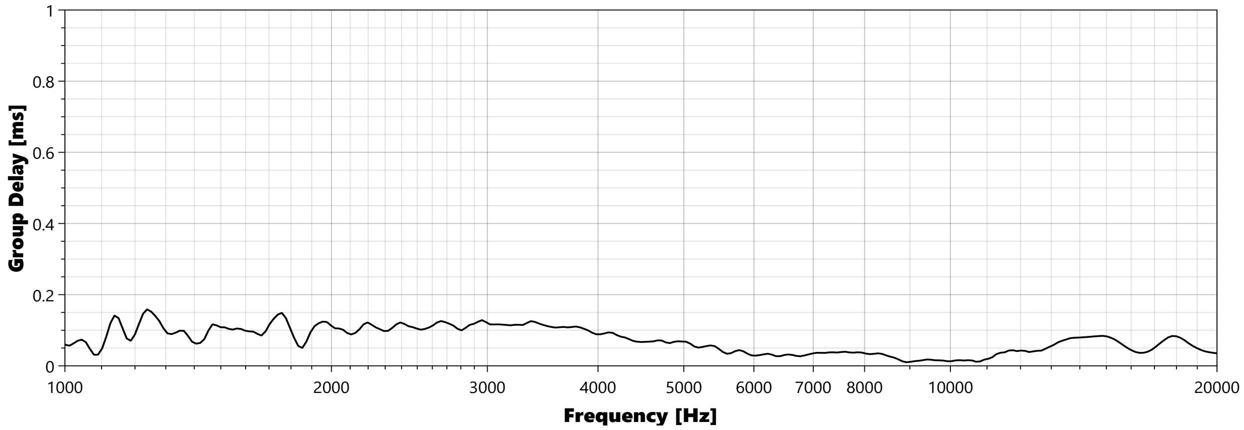


Figure 9: **Group delay; sampling frequency 96 kHz.**

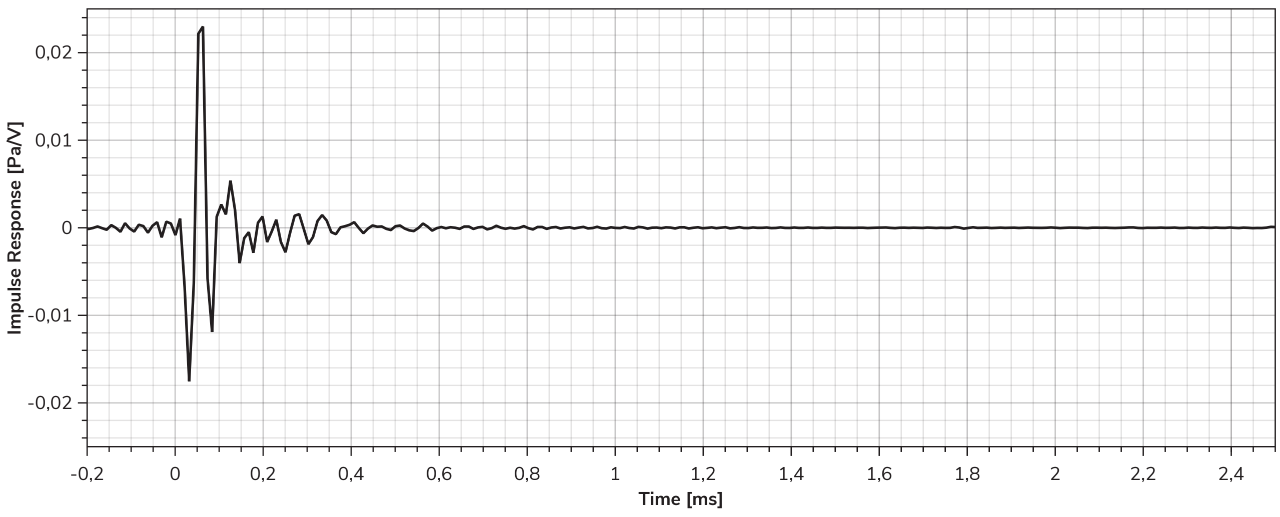


Figure 10: **Impulse response; measured at 15 V_P; sampling frequency 96 kHz.**

ACOUSTIC PERFORMANCE IN COUPLER

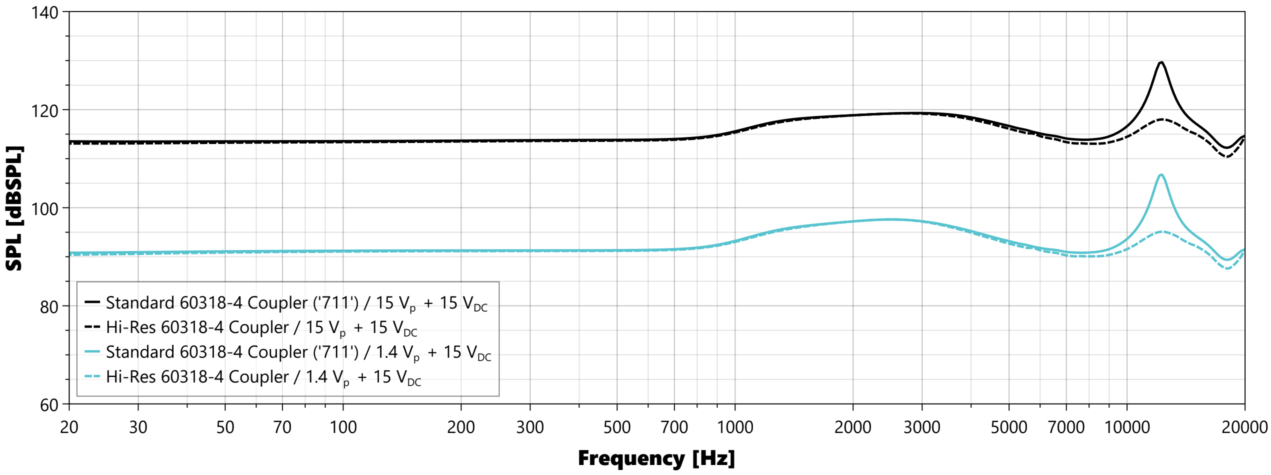


Figure 11: SPL at 15 V_P + 15 V_{DC} and at 1.4 V_P + 15 V_{DC} drive, measured with the standard 711-Coupler (IEC 60318-4) and with the Hi-Res Coupler from GRAS. The latter replicates the frequency response above 10 kHz more accurately.

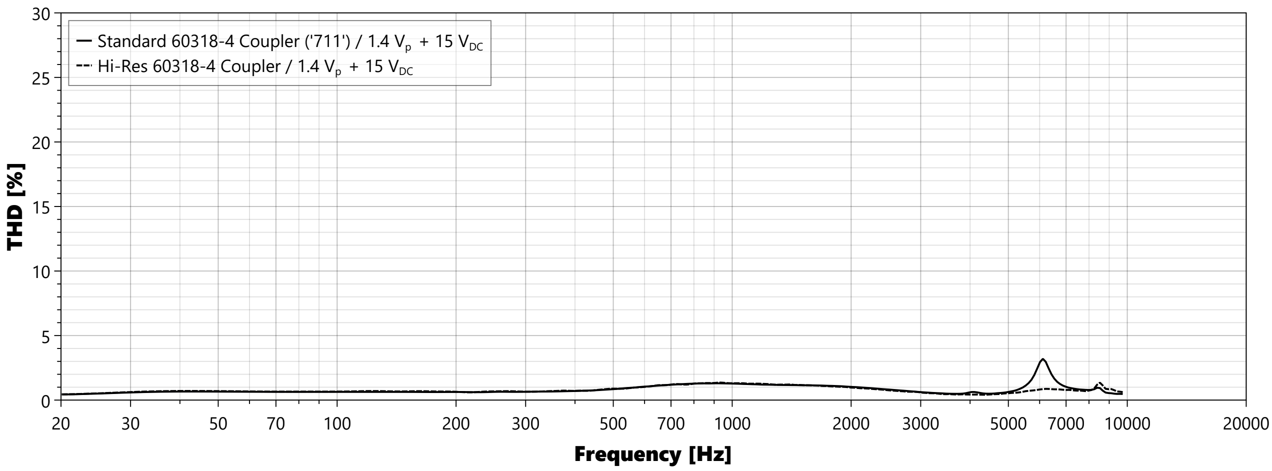


Figure 12: THD at 1.4 V_P + 15 V_{DC} drive, measured with the standard 711-Coupler (IEC 60318 4) and with the Hi-Res Coupler from GRAS. The latter replicates the THD above 3 kHz more accurately (see GRAS Whitepaper).

ACTIVE LINERARIZATION ALGORITHM

The Active Linearization Algorithm ('ALA') is a signal processing algorithm developed by USound that optimizes the audio signal to compensate for non-linearities in the speaker. Appling it lowers the THD further, while keeping the SPL unchanged (difference below 0.5 dB).

Adap UT-P2023 is mainly showing significant THD improvements by applying ALA in the frequency range up to 5 kHz. Due to their used MEMS technology and mechanical structure, the non-linearities are less susceptible to the predistortion and the hysteresis compensation.The reduction of the THD using ALA implementation for Adap UT-P2023 in occluded applications is demonstrated in **Figure 13**. For free field applications ALA is not efficient.

Please see USound's whitepaper on the ALA topic or contact sales@usound.com for further support.

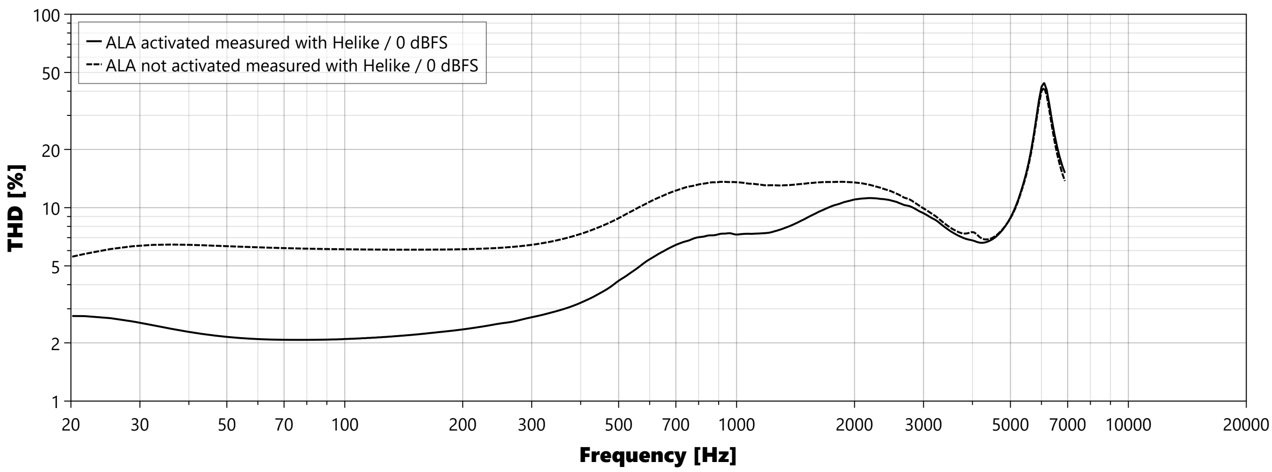


Figure 13: THD at maximum output of Adap UT-P2023 measured with Helike 1.0 UA-E3010 in standard 711-Coupler (IEC 60318-4), with and without ALA activated.

ACOUSTIC PERFORMANCE USING CARME KIT

The Carme kit UJ-E1040G00 is a speaker evaluation kit for the Adap UT-P2023 USound MEMS speaker, enabling easy electrical connection for acoustic measurements both in free field conditions as well as with a standard coupler (IEC-60318-4).

The speaker box (Figure 14) is part of the Carme kit and it has a back volume of 100 mm³. The speaker box closed with a PCB provides the necessary sealing to avoid an acoustic short circuit and offers a convenient way to connect Adap UT-P2023 to USound's amplifier boards.

To set up the Carme speaker box, unscrew and separate the PCB from the shell. Remove the housing gasket and place the MEMS speaker inside the box with the contact side up. Place the PCB by taking care to match the orientation marks with those on the speaker. Tighten the screws for proper sealing. Using the Carme speaker box, Adap UT-P2023 MEMS speakers can be measured in free field (Figure 15).

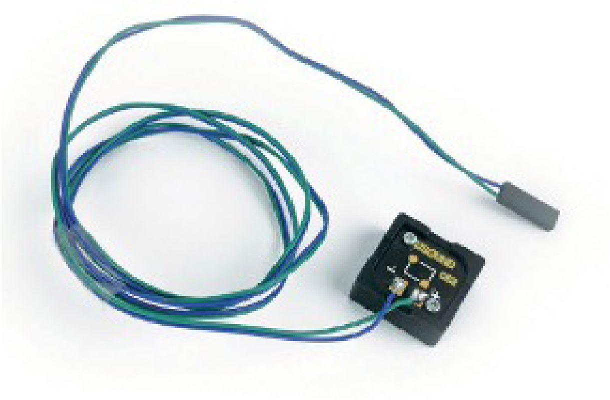


Figure 14: **Speaker box of the Carme kit UJ-E1040G00 assembled with cable.**

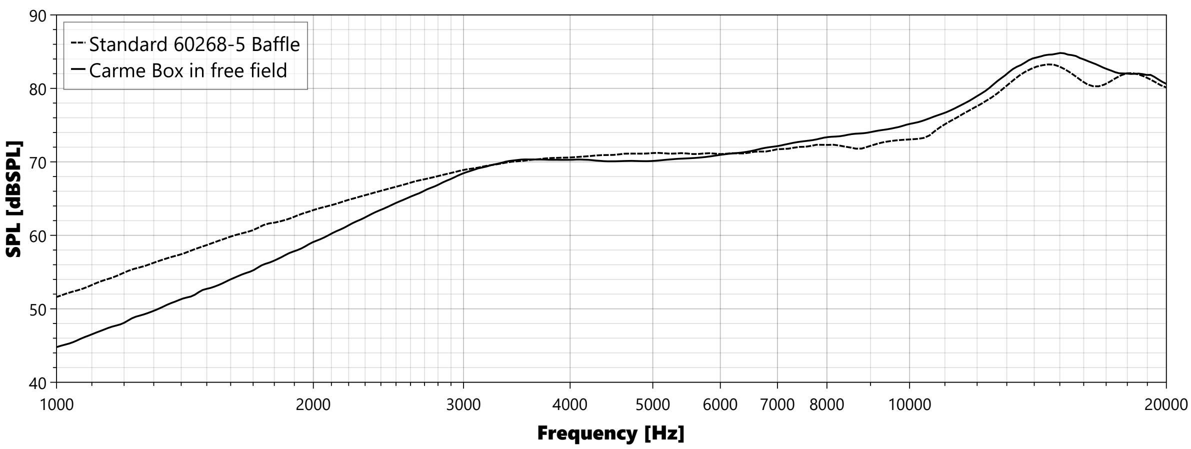


Figure 15: **SPL at maximum output, measured with the standard Baffle (IEC 60268-5) and in the speaker box of the Carme kit UJ-E1040G00 in free field (10 cm).**

HANDLING

GENERAL

It needs to be considered that MEMS devices consist of silicon structures and therefore, they should be handled with care. Any bending of the MEMS speakers must be avoided while handling during the assembly process and when permanently inside an application, otherwise the speaker can be damaged.

TWEEZERS

It is recommended to gently grip the speakers from the sides with blunt curved tweezers and avoid touching the membrane under any circumstances to preserve its functionality and form. Using sharp tweezers while manipulating the speakers can lead to accidentally piercing the membrane and to a loss of functionality.

The risk to damage the speaker can be further minimized if the speaker is handled with the membrane facing down, as shown in the picture below.

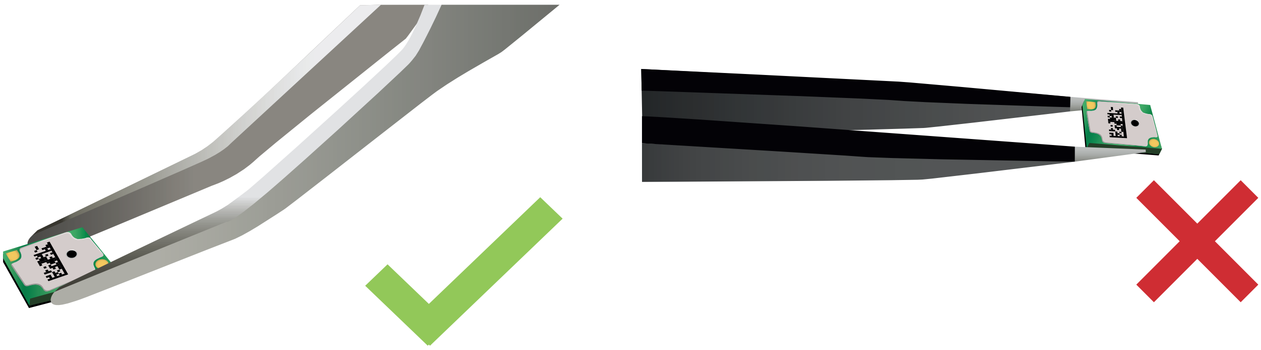


Figure 16: **Left: Recommended tweezer type. Right: Not recommended tweezer type.**

INTEGRATION

It needs to be considered that MEMS devices consist of silicon structures and therefore, they should be handled with care. Any bending of the MEMS speakers must be avoided while handling during the assembly process and when permanently inside an application, otherwise the speaker can be damaged.

To avoid bending of the speaker, it's recommended that just the defined contact areas are in contact with the application at front side and back side of the speaker.

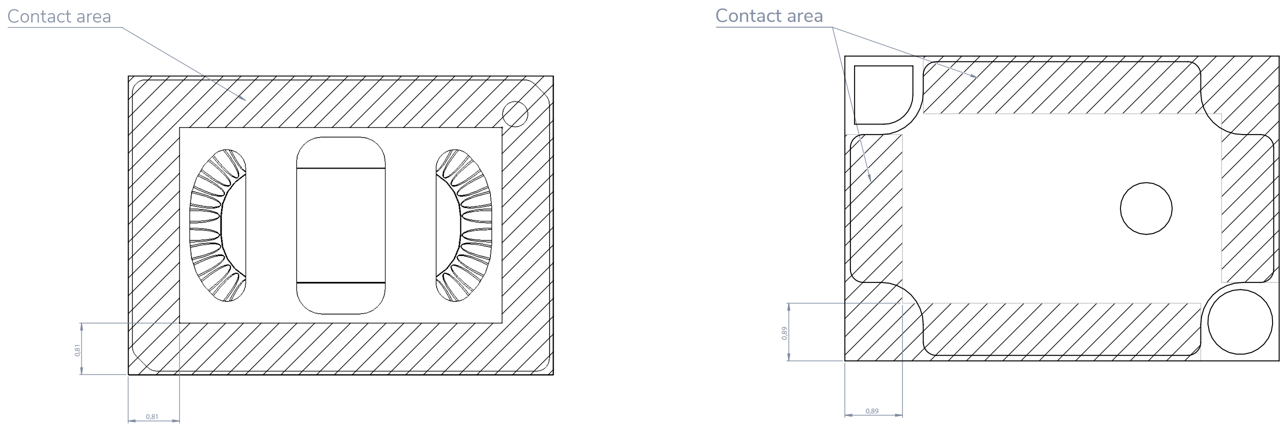
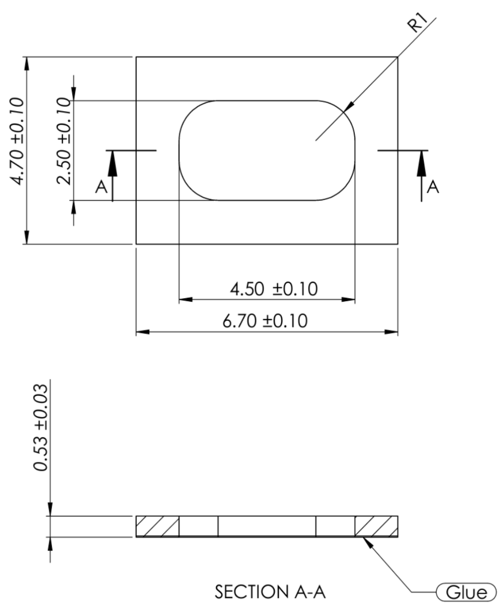
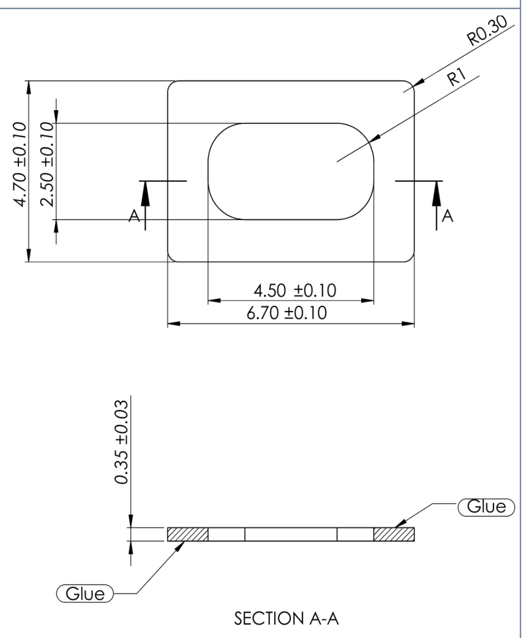


Figure 17: Recommended contact surfaces at the front side (left) and back side (right) of MEMS speaker.

SPEAKER GASKETS

In most applications the speakers need to be sealed to deliver the proper performance. This can be attained by various means, gaskets being the most prominent. USound offers two standard gaskets optimized for different applications. Both designs have the same footprint as the speaker and an opening similar to the cover opening.

Name	UG-P201G	UG-P202G
Description	Open cell foam gasket with a glue layer on one side.	Closed cell foam gasket with a glue layer on each side.
Material	Poron 4701-50-30020-04 & TESA 4983	TESA 75635
Thickness uncompressed (compressed for proper sealing)	0.53 mm (0.30 mm)	0.35 mm (0.35 mm)
Application recommendations	Suitable for prototyping The speaker needs to be pushed on the gasket in order to be sealed, some mechanical tolerance can be absorbed. Main application is prototyping and evaluation, where the speaker can be exchanged.	Suitable for mass production The speaker does not need to be pressed against the gasket; sticking it to the gasket during assembly is enough. Main application is mass production where the speaker is mounted permanently. Disassembly will not be possible.
Drawings	 *Delivery on carrier sheets (matrix distribution).	 *Delivery on carrier sheets (matrix distribution).

CONNECTIVITY

The speaker is driven by applying voltage between the + and the - connection. The potential of + has to be always equal or higher than the -. To ensure this a DC voltage together with the AC signal has to be applied on +.

Attention: The AC peak voltage must always be smaller than or equal to the DC voltage.

The membrane will move downwards/inside by applying a positive voltage on the + connection.

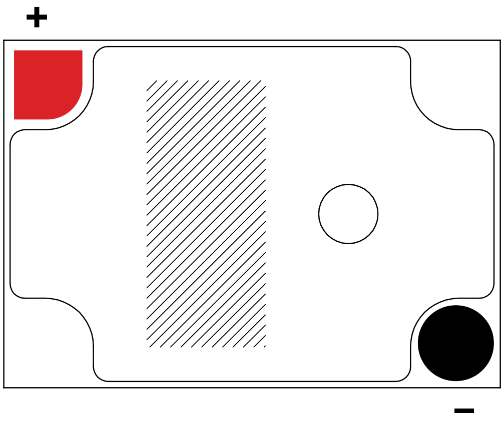


Figure 18: **Electrical connections of the speaker back side.**

LABELING

Each speaker is equipped with an 8 x 18 digital matrix code (DMC).

- DMC Size: 3.6 mm x 1.6 mm
- Pixel size: 0.2 mm
- Data format corresponds to the production date: NNYCCDSSSS. For example: 0191024022

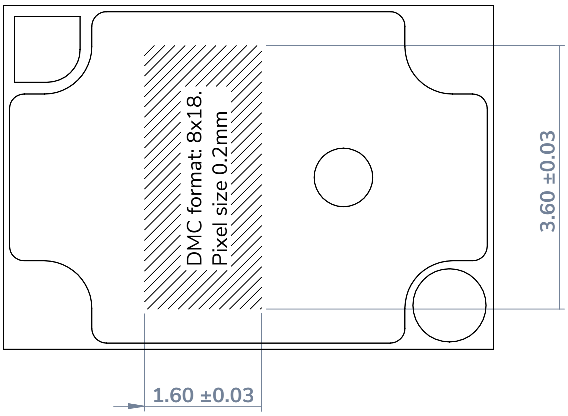


Figure 19: **DMC at speaker backside.**

02	9	10	2	4022
NN	Y	CC	D	SSSS
Speaker type (01 = Adap UT-P2023; 02= Achelous UT-P2020)	Year (Last digit of the year)	Calendar week	Week day (First day starts on Sunday)	Serial number

PACKAGING

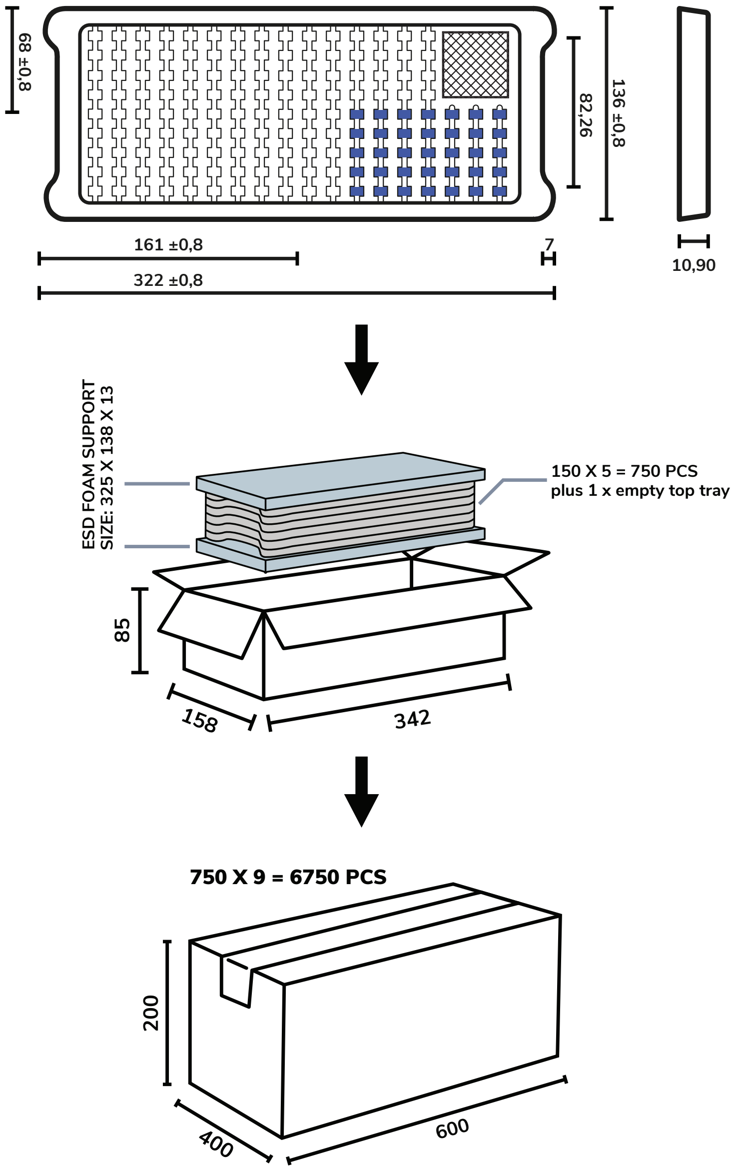


Figure 20: **Packaging in tray and carton.**

RELATED DOCUMENTATION

Adap UT-P2023 - Info Sheet
USound MEMS Speaker - Handling Guide
USound MEMS Speaker - Unboxing Guide

SIMILAR PRODUCTS

Product Name	Description
Achelous UT-P2020	MEMS speaker for in-ear audio solution, hearables, full-bandwidth, rectangular and metal cover.
Achelous UT-P2016	MEMS speaker for in-ear audio solution, hearables, full-bandwidth, rectangular and plastic cover.

COMPATIBLE PRODUCTS

Product Name	Description
Amalthea 1.0 UA-R3010	MEMS speaker array amplifier with frequency range up to 80 kHz, can drive up to 40 MEMS speakers, including heatsink housing.
Helike 1.0 UA-E3010	Development board for evaluating, rapid prototyping and designing audio solutions using USound MEMS speaker technology.
Carme kit UJ-E1040G00	A speaker evaluation kit for testing the acoustic performance of USound MEMS speakers Adap and Achelous.
Tarvos 1.0 UC-P3010	ASIC linear audio amplifier with analog input to drive the USound MEMS speakers.
Tarvos Evaluation Board 1.0 UC-E3010	Evaluation board for testing key features of the USound ASIC linear audio amplifier.

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