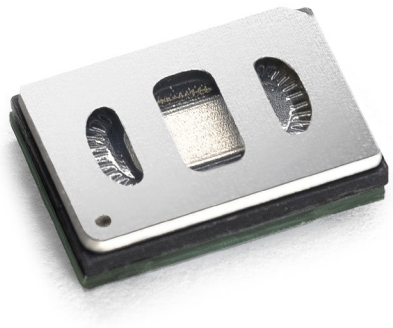
MEMS SPEAKERS

ACHELOUS UT-P2020 | DATASHEET



Achelous UT-P2020 is a MEMS speaker that is ideal for in-ear audio solutions such as wired earphones or true wireless systems (TWS). Achelous UT-P2020 offers maximum flexibility for outstanding design approaches. As a speaker with a wide bandwidth, it produces vivid, clear and rich sound.

FEATURES

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

APPLICATIONS

The Achelous UT-P2020 speakers can be used for in-ear audio systems such as wired and true wireless (TWS) earphones. It enables Hi-Res audio applications.

CONTENT

REVISION HISTORY

February 2021: Release
May 2021: Updated section “Acoustic performance using the Carme UJ-R1020/UJ-R1030 test box on coupler”, page 10; power consumption values added, page 3; capacity value adjusted, page 3; added section “Speaker gaskets”, page 14
July 2023: Updated values in Specifications table, page 3; Updated Acoustic Performance section, page 8

SPECIFICATIONS

General acoustics			
f_{res}	[kHz]	2.7	±10%
Q-factor	[-]	0.6	
Effective membrane surface – S_D	[mm²]	12	
Equivalent volume – V_{AS}	[mm³]	60	
Front volume inside speaker	[mm³]	5.6	
Back volume inside speaker	[mm³]	20	

Acoustics in coupler (IEC 60318-4)			
SPL @ 250 Hz / 10.6 V_{RMS} (15 V_P) + 15 V_{DC}	[dB]	116	±3.0
SPL @ 1 kHz / 10.6 V_{RMS} (15 V_P) + 15 V_{DC}	[dB]	118	±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]	115	±3.0
SPL @ 250 Hz / 1 V_{RMS} (1.4 V_P) + 15 V_{DC}	[dB]	94	±3.0
SPL @ 1 kHz / 1 V_{RMS} (1.4 V_P) + 15 V_{DC}	[dB]	95	±3.0
SPL @ 5 kHz / 1 V_{RMS} (1.4 V_P) + 15 V_{DC}	[dB]	92	±3.0
THD @ 250 Hz / 1 V_{RMS} (1.4 V_P) + 15 V_{DC}	[%]	0.3	+0.3
THD @ 1 kHz / 1 V_{RMS} (1.4 V_P) + 15 V_{DC}	[%]	0.4	+0.3
THD @ 5 kHz / 1 V_{RMS} (1.4 V_P) + 15 V_{DC}	[%]	0.6	+0.3

Electronics			
Capacitance	[nF]	27	±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

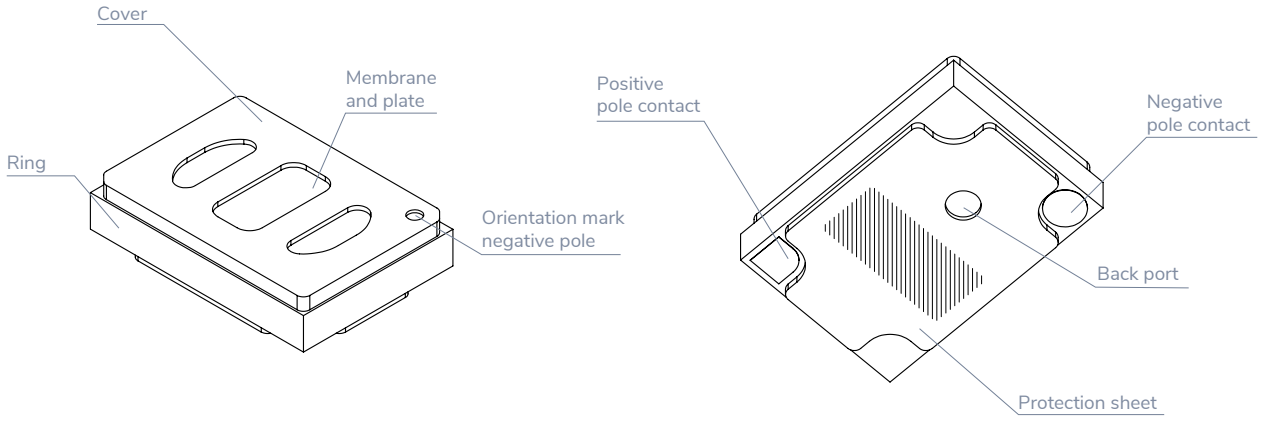


Figure 1: **Speaker perspective view.**

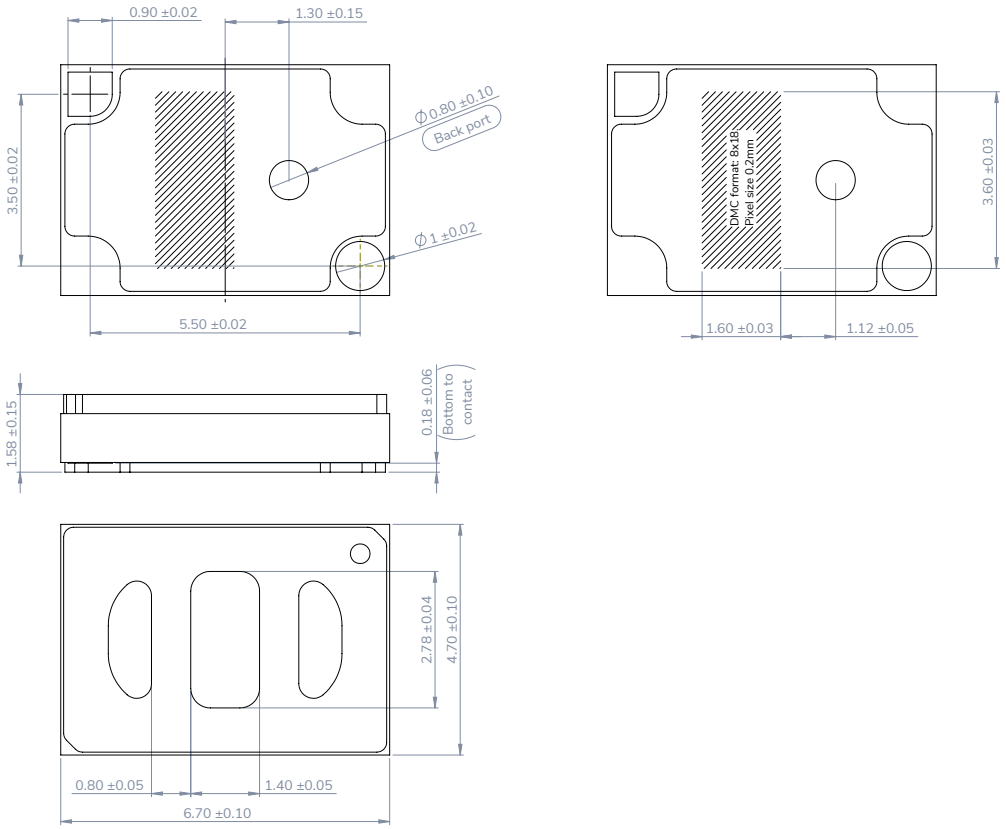


Figure 2: **Speaker bottom/side/top views. Dimensions in mm.**

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

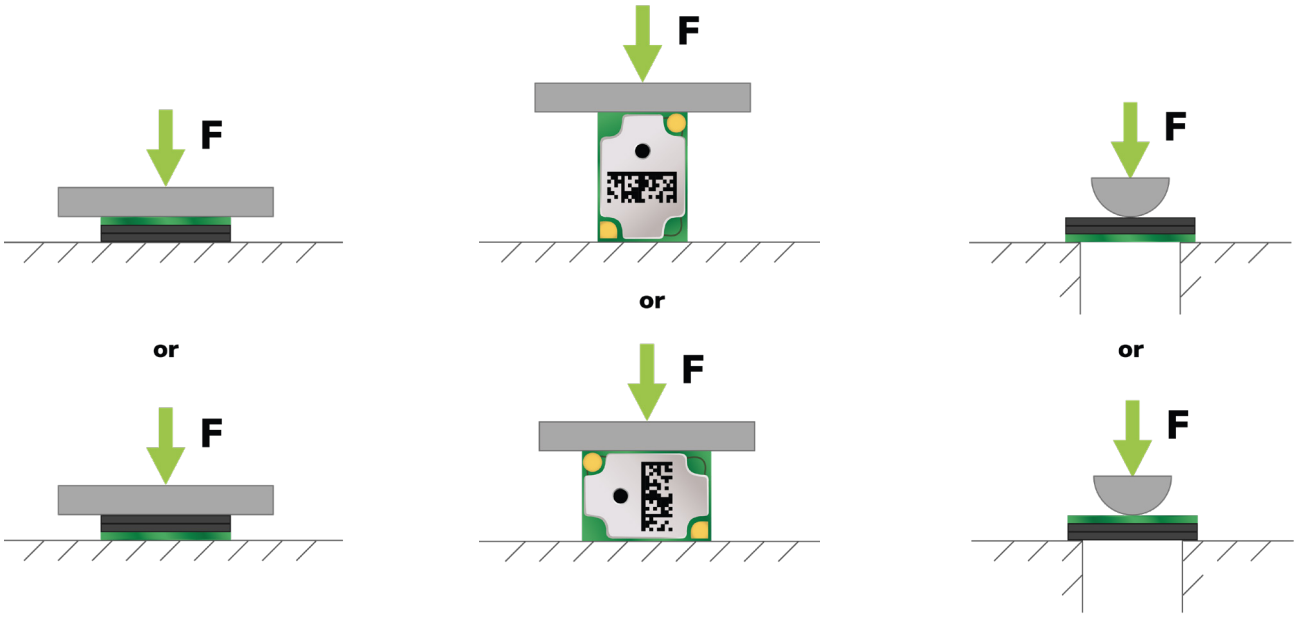


Figure 3: **Left: front face compression, centre: side face compression, right: 3-point bending.**

TEST CONDITIONS

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

Coupler	
Coupler type	IEC 60318-4 (711)
Coupler volume	1.26 cm^3
Connection tube length	1.5 mm
Connection tube diameter	3.00 mm
Microphone	GRAS 43AC

COUPLER MEASUREMENT ADAPTER

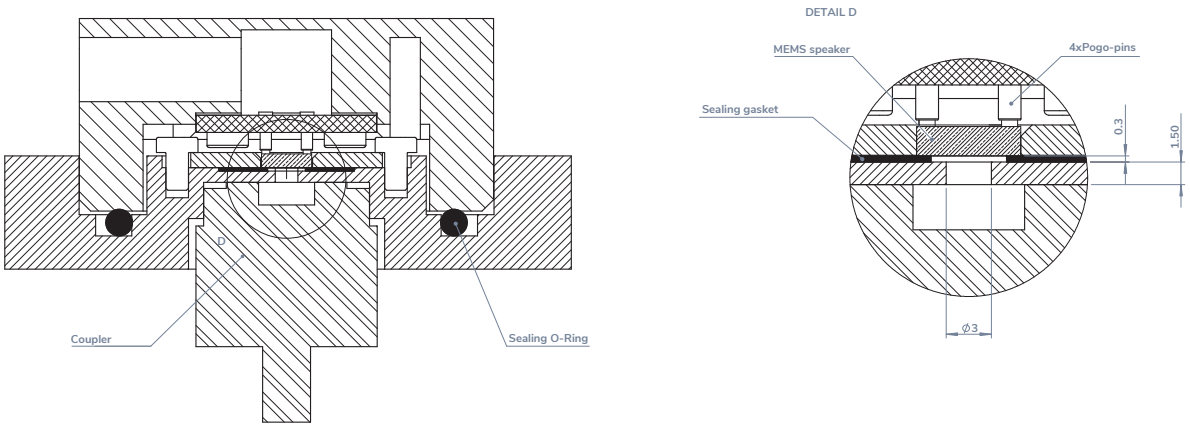


Figure 4: Coupler adapter cross-section. The speaker adapter is directly screwed onto the coupler; the earmould adapter is not used. The outlet for the speaker is round with a diameter of 3 mm and length of 1.5 mm, as shown in Detail D.

For customers, USound offers a speaker evaluation kit (Carme kit UJ-E1040G00) to replicate the coupler adapter design above. Using the Carme kit, the same results as in the datasheet can be obtained.

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 is based on the typical application diagram from the LM48580 datasheet. It is based on a single-ended input signal but can be also modified according to the datasheet to a differential input.

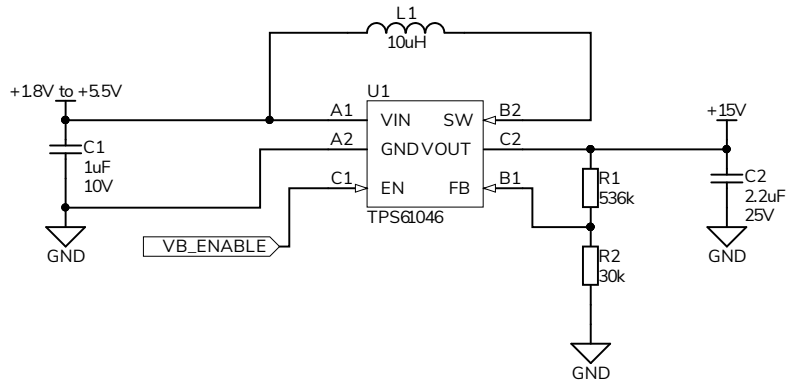


Figure 5: **TPS61046 boost converter including required passive components.**

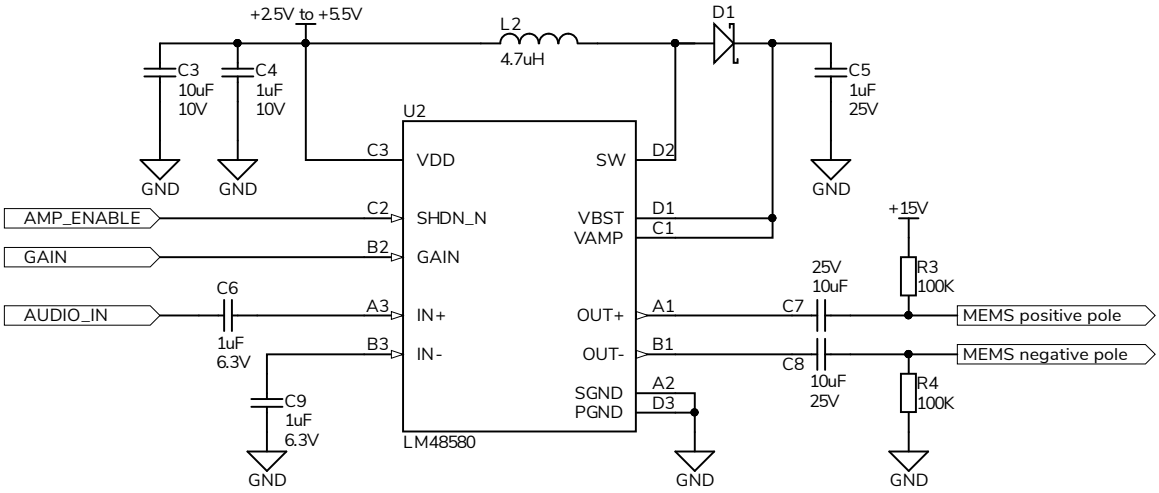


Figure 6: **LM48580 amplifier, including required passive components.**

ACOUSTIC PERFORMANCE

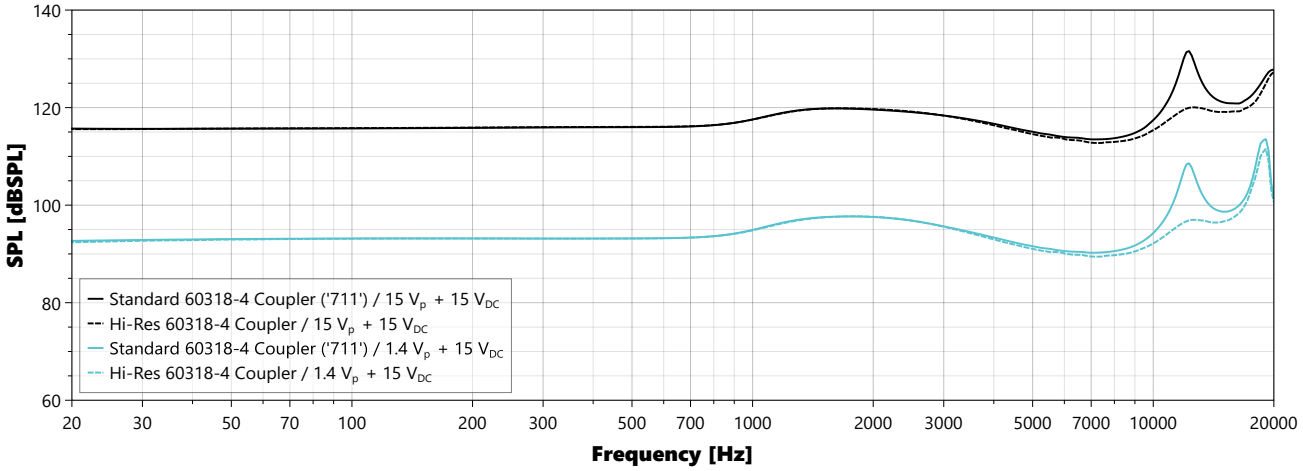


Figure 7: SPL at 15 V_P + 15 V_{DC} and 1.4 V_P + 15 V_{DC} drive, measured with the standard 711-Coupler (IEC 60318-4) and with the Hi-Res Coupler from GRAS. The latter replicates the frequency response above 10 kHz more accurately.

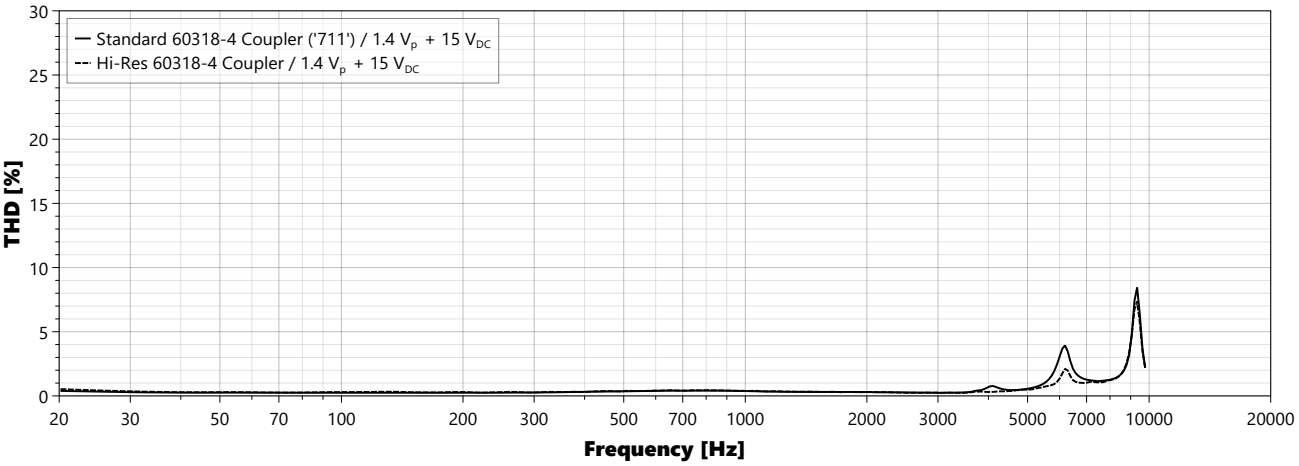


Figure 8: THD at 1.4 V_P + 15 V_{DC} drive, measured with the standard 711-Coupler (IEC 60318-4) and with the Hi-Res Coupler at 1.4 V_P + 15 V_{DC} from GRAS. The latter replicates the THD above 3 kHz more accurately (see GRAS Whitepaper).

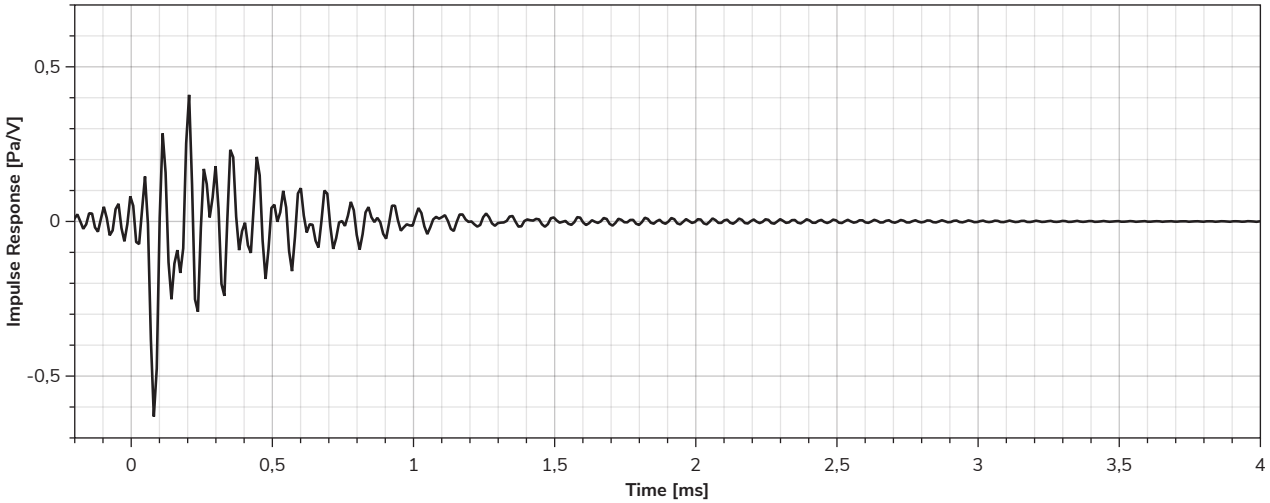


Figure 9: **Impulse response, measured at 15 Vp; sampling frequency 96 kHz.**

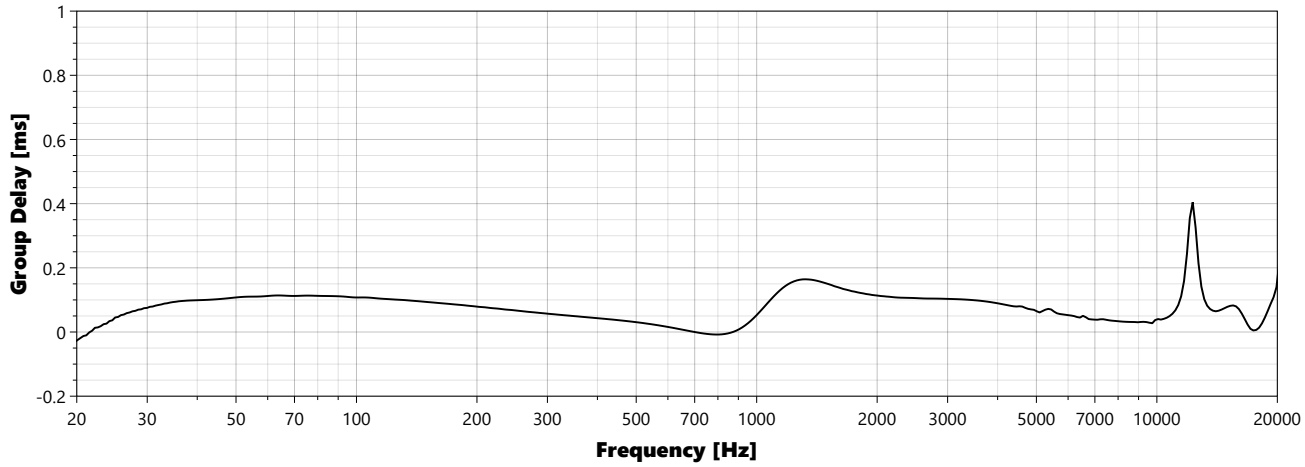


Figure 10: **Group delay; sampling frequency 96 kHz.**

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. Applying it lowers the THD further, while keeping the SPL unchanged (difference below 0.5 dB).

Achelous UT-P2020 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 Achelous UT-P2020 is demonstrated in **Figure 11**.

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

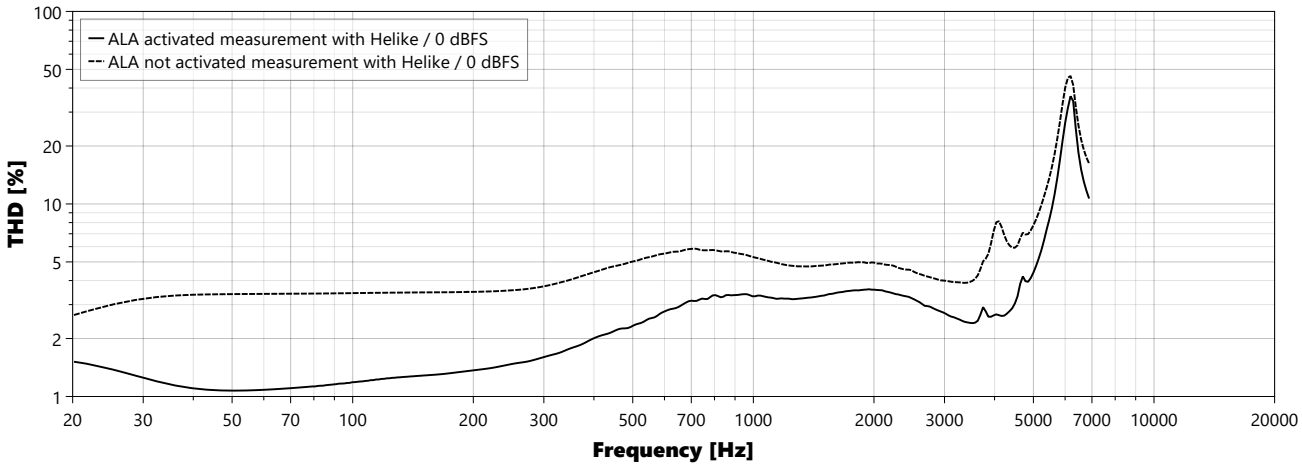


Figure 11: THD at maximum output of Achelous UT-P2020 measured with Helike 1.0 UA-E3010 in standard 711-Coupler (IEC 60318-4) from GRAS, with and without ALA activated.

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.

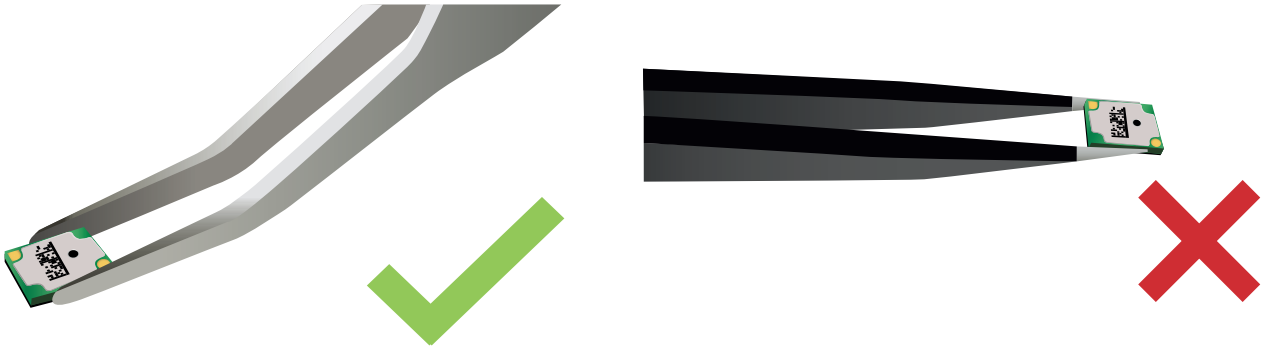


Figure 12: **Left: Recommended tweezer type. Right: Not recommended tweezer type.**

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.

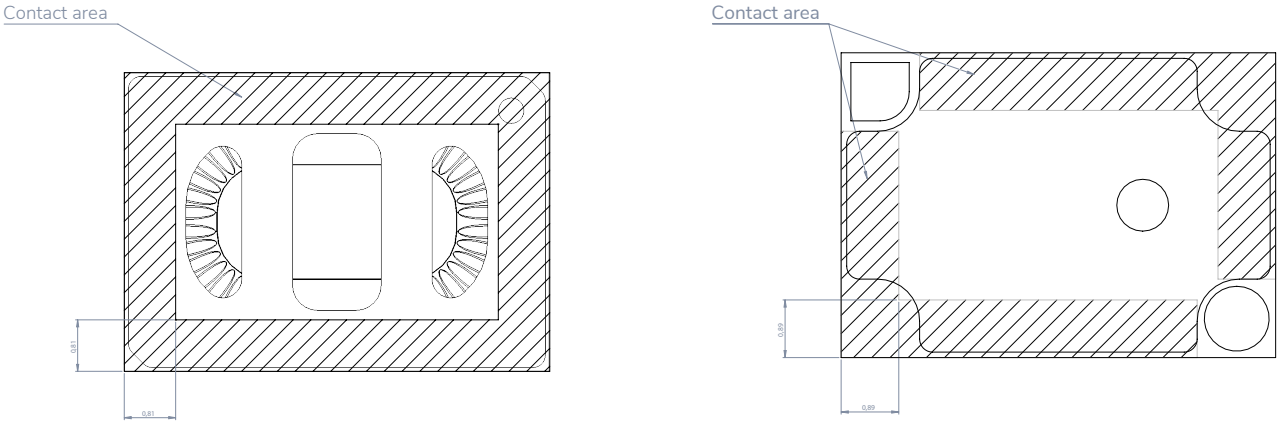
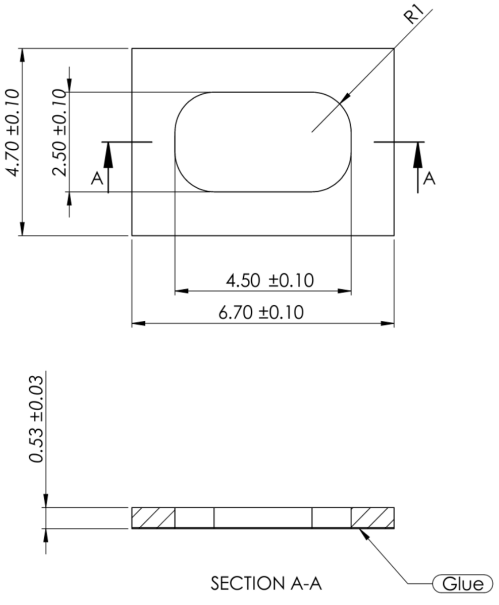
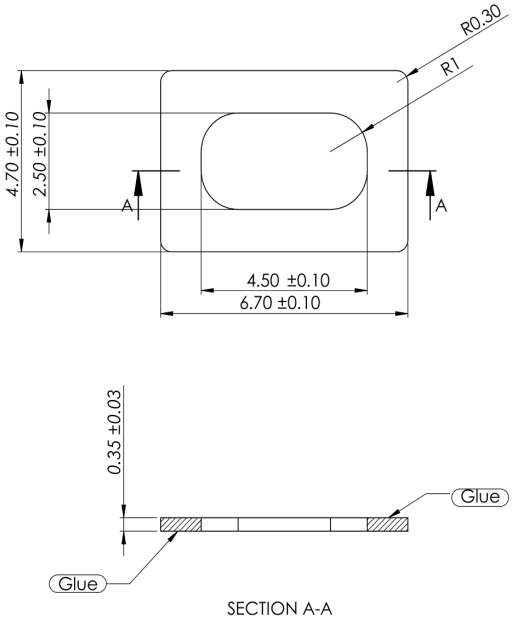


Figure 13: **Recommended contact surfaces at the front side (left) and back side (right) of MEMS speaker.**

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.

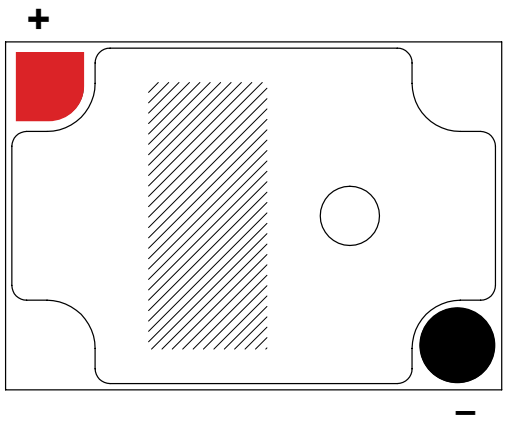


Figure 14: **Electrical connections of the speaker back side.**

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

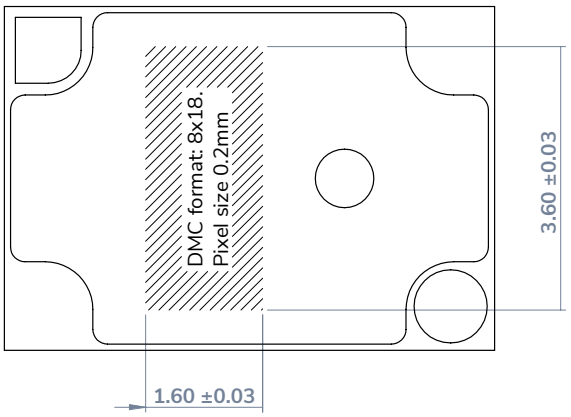


Figure 15: **DMC at speaker backside.**

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

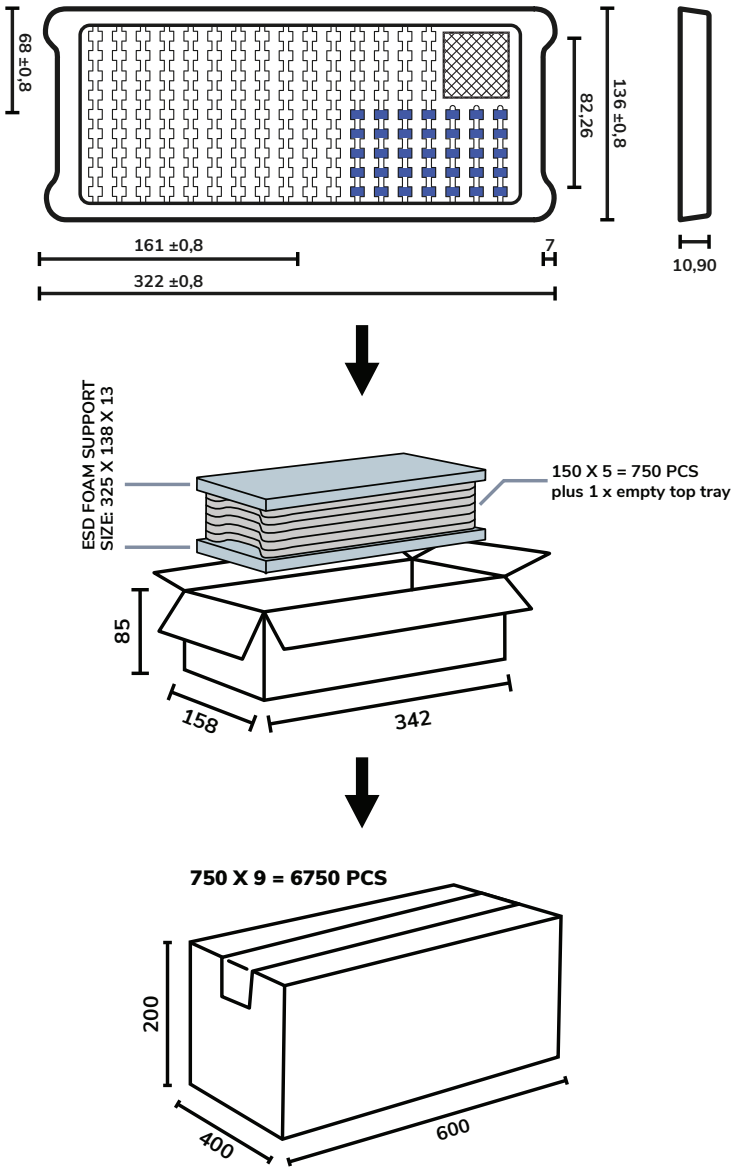


Figure 16: **Packaging in tray and carton.**

RELATED DOCUMENTATION

Achelous UT-P2020 – Info sheet
USound MEMS Speaker - Handling Guide
USound MEMS Speaker - Unboxing Guide

SIMILAR PRODUCTS

Product Name	Description
Adap UT-P2023	MEMS speaker for free-field applications, wearables, rectangular, 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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