

# MEMS SPEAKERS

ACHELOUS UT-P 2016 | DATASHEET

U))) SOUND



Achelous MEMS speakers are ideal for in-ear audio solutions such as wired earphones or true wireless systems (TWS). Thanks to its small size and low weight, Achelous, offers maximum flexibility for outstanding design approaches. As a wide bandwidth speaker, it enables high-res audio applications. Achelous produces vivid, clear and rich sound, immersing the listener into their personal audio environment.

## FEATURES

- Full bandwidth achieved with a single MEMS speaker
- Enables modern, lightweight and ergonomic designs for wired earphones and TWS
- Seamless integration into acoustics devices
- Longer battery life due to the speaker's low power consumption
- Competitive sound pressure level
- No magnetic field
- Low heat generation

## APPLICATIONS

The Achelous speakers can be used for in-ear audio systems such as wired earphones, and true wireless systems (TWS).

## **CONTENT**

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## **REVISION HISTORY**

September 2019: Acoustic performance — added impulse response and group delay, page 8

December 2019: Force on speaker, page 5 and integration, page 12

## SPECIFICATIONS

General acoustics			
$f_{res} @ 15 V_p$	[kHz]	2.7	±10%
$Q @ f_{res} / 15 V_p$	[-]	0.6	
Effective membrane surface – $S_D$	[mm <sup>2</sup> ]	12	
Equivalent volume – $V_{AS}$	[mm <sup>3</sup> ]	60	
Front volume inside speaker	[mm <sup>3</sup> ]	5.6	
Back volume inside speaker	[mm <sup>3</sup> ]	20	

Acoustics in coupler (IEC 60318-4)			
SPL @ 250 Hz / 15 $V_p$	[dB]	115	±3.0
SPL @ 1 kHz / 15 $V_p$	[dB]	117	±3.0
SPL @ 5 kHz / 15 $V_p$	[dB]	115	±3.0
SPL @ 250 Hz / 1 $V_{rms}$ (1.4 $V_p$ )	[dB]	92	±3.0
SPL @ 1 kHz / 1 $V_{rms}$ (1.4 $V_p$ )	[dB]	94	±3.0
SPL @ 5 kHz / 1 $V_{rms}$ (1.4 $V_p$ )	[dB]	92	±3.0
THD @ 250 Hz / 1 $V_{rms}$ (1.4 $V_p$ )	[%]	0.2	+0.3
THD @ 1 kHz / 1 $V_{rms}$ (1.4 $V_p$ )	[%]	0.3	+0.3
THD @ 5 kHz / 1 $V_{rms}$ (1.4 $V_p$ )	[%]	0.4	+0.3
Lower bandwidth (-3 dB)	[Hz]	<20	

Electronics			
Capacity @ 1 kHz / 15 $V_p$	[nF]	37	±20%

Operating conditions			
Maximum AC voltage (peak) – up to 40 kHz	[ $V_p$ ]	15	
Maximum DC voltage	[V]	15	
Maximum AC current (peak)	[mA <sub>p</sub> ]	200	

Power consumption			
with white noise @ 94 dB	[mW]	19.8	
with pink noise @ 94 dB	[mW]	17.4	
with IEC noise (60268-1) @ 94 dB	[mW]	13.6	

\*Power consumption test conditions can be found in page 6.

## MECHANICAL DIMENSIONS

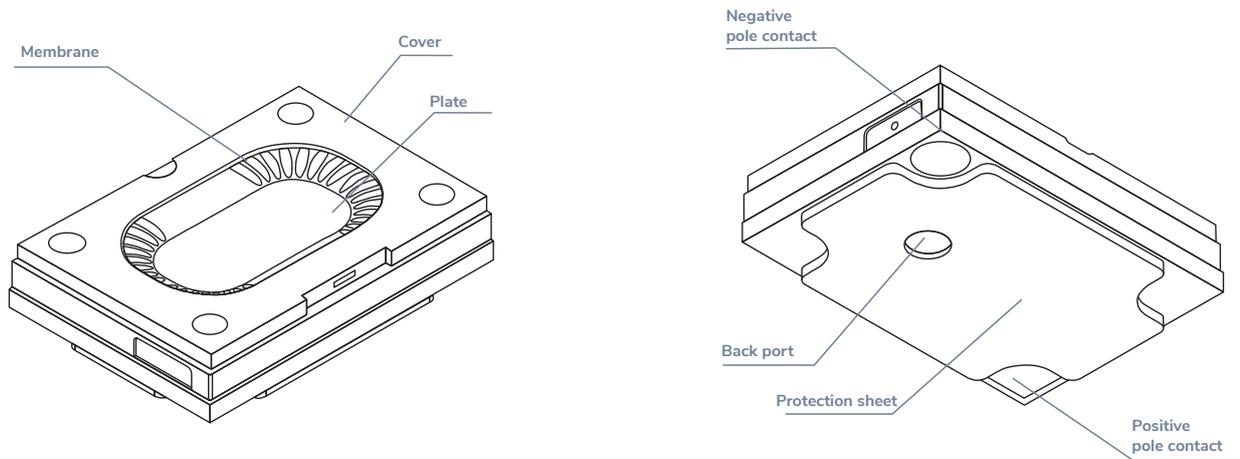


Figure 1: Mechanical drawings: perspective view

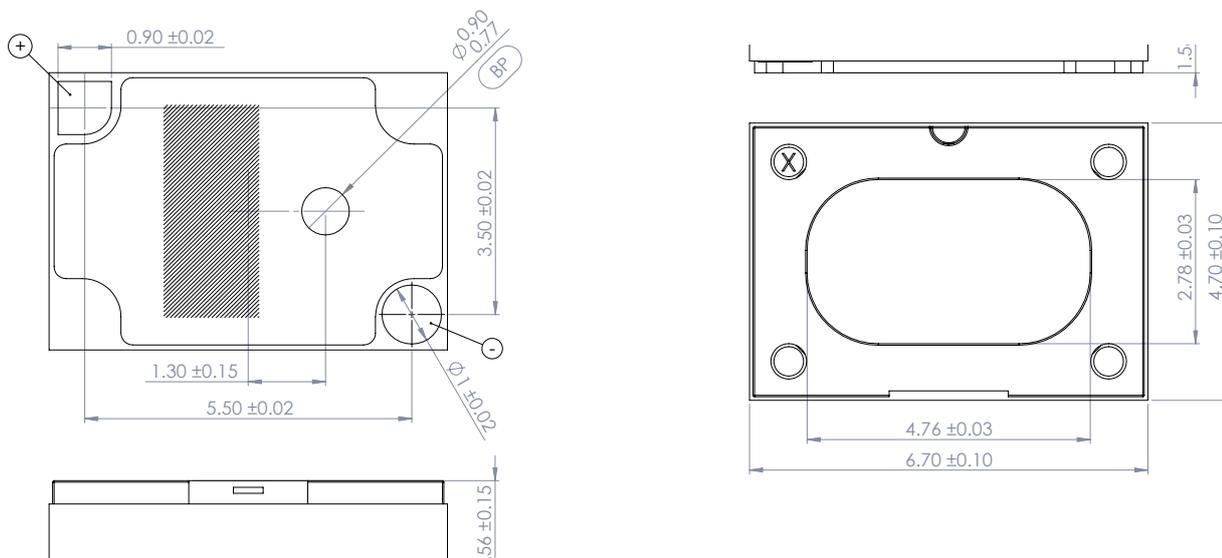


Figure 2: Mechanical drawings: top/down/side view

Mechanics		
Size	[mm]	6.7 x 4.7 x 1.56
Total speaker weight	[mg]	47
Total speaker cubic volume	[mm <sup>3</sup> ]	49

## FORCE ON SPEAKER

Type of stress	Maximum handling force [N]	Maximum permanent force [N]
Front face compression	20	13
Side face compression	10	7
3 point bending	3	2
Force on membrane	0	0

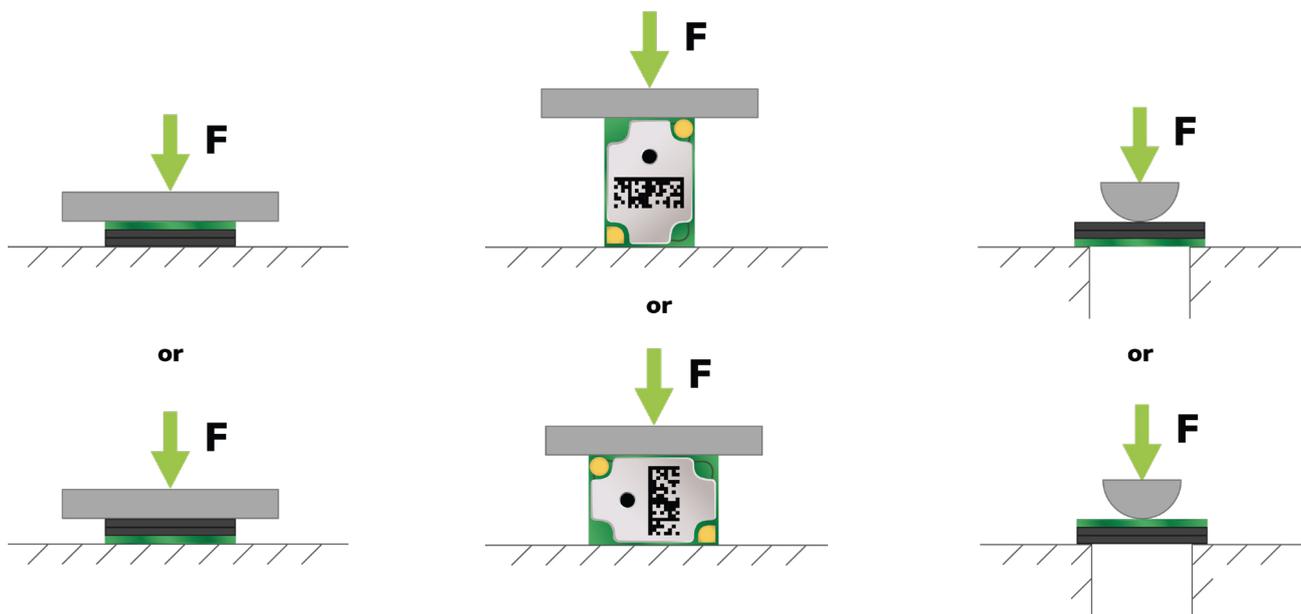


Figure 3: Left: front face compression, centre: side face compression, right: 3-point bending

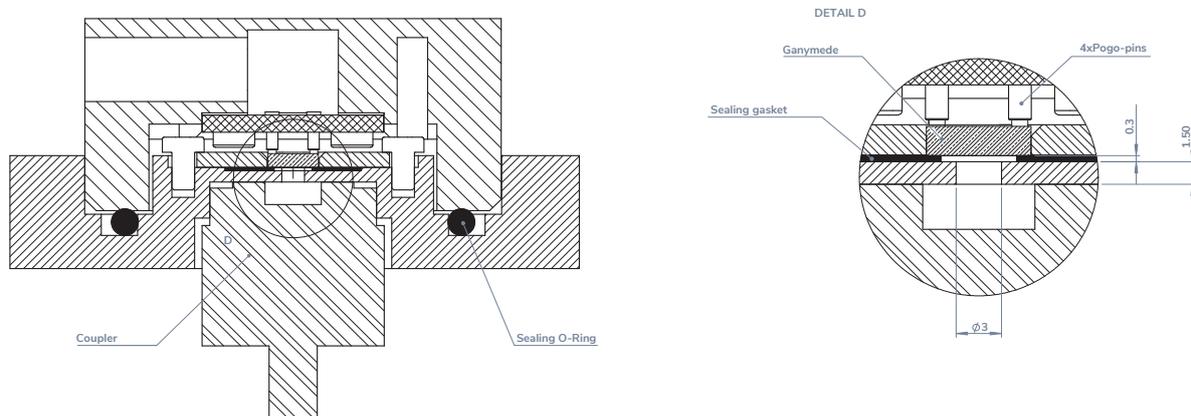
## TEST CONDITIONS

### ACOUSTICS

General	
Measurement system	Audio Precision APx
Measurement signal	Exp. Sweep
Voltage levels – audio $V_{DC} + V_{AC}$	15 V + 15 V <sub>p</sub>
Applied back volume	Open (infinite)

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

### COUPLER MEASUREMENT ADAPTER

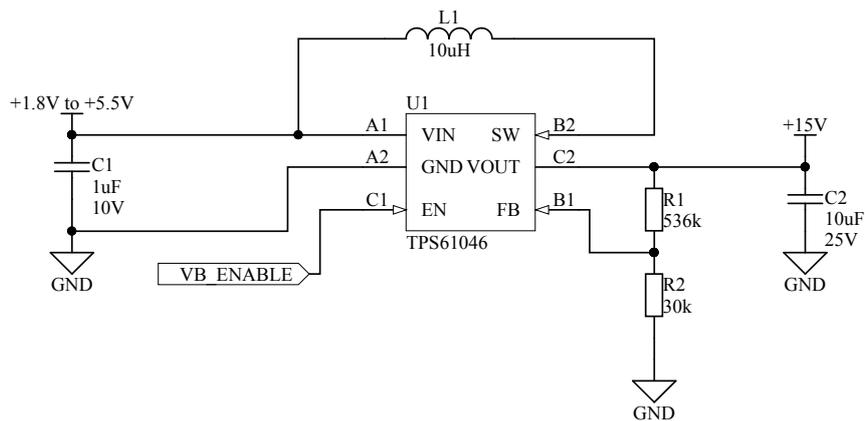


**Figure 4:** Coupler adapter cross-section. The outlet of the coupler for the speaker is round with a diameter of 3 mm, as shown in Detail D

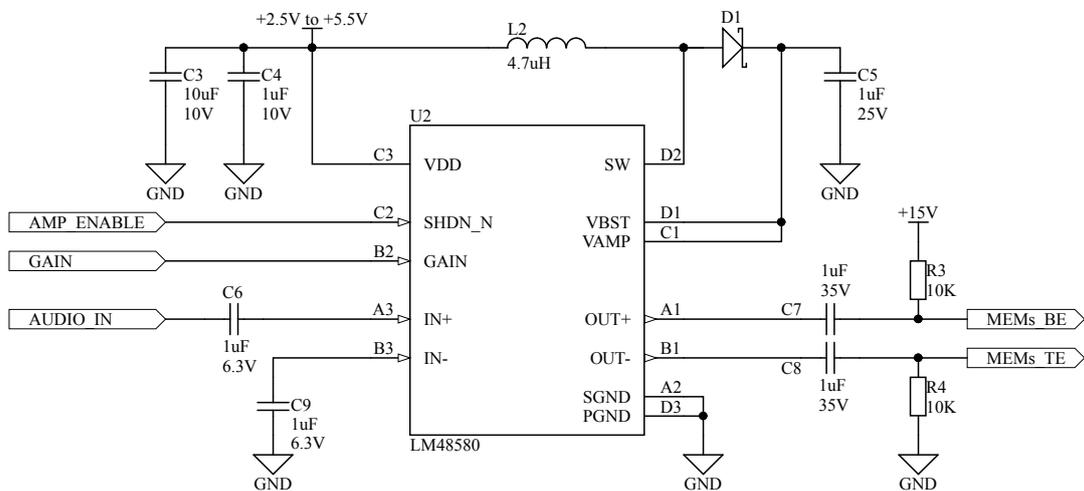
**POWER CONSUMPTION**

Power consumption is measured with one Achelous MEMS speaker, including the typical driving circuitry with the DC boost converter TPS61046 and the amplifier TI LM4858. The main blocks are presented in Figure 2 and Figure 3.

Condition: Supply voltage 3.6 V; audio output 94 dB in coupler.



**Figure 5: TPS61046 boost converter, including needed passive components**



**Figure 6: LM48580 amplifier including needed passive components**

The boost converter is configured to provide a constant 15 V<sub>DC</sub> offset for the amplifier. 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.

## ACOUSTIC PERFORMANCE

### ACOUSTIC PERFORMANCE IN COUPLER (IEC 60318-4)

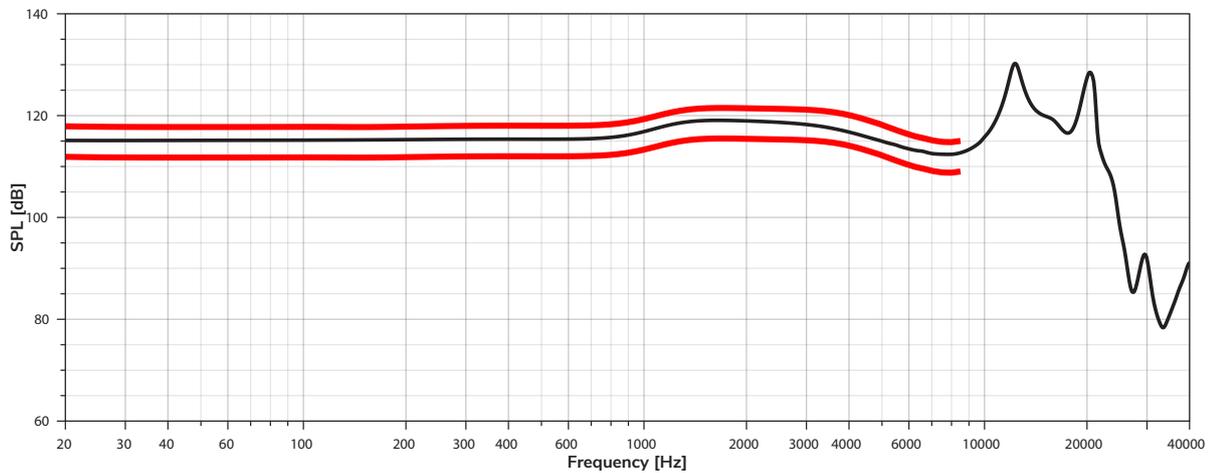


Figure 7: SPL @ 15 V<sub>p</sub> drive\*

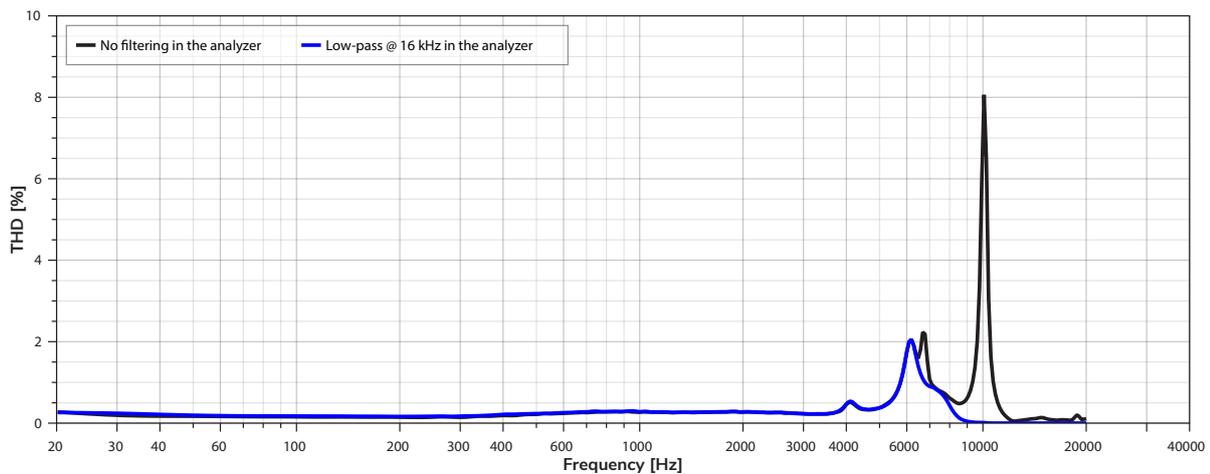


Figure 8: THD 94 dB SPL @ 1 kHz, corresponds 1 V<sub>rms</sub> (1.4 V<sub>p</sub>)\*\*

\*Red lines in figure 4 indicate the limits. Test limits are used to establish incoming inspection acceptance / rejection criteria, correlation of test equipment with USound is also required for elimination of equipment and test method variation.

\*\*Low pass filter @ 16 kHz (see figure 5) is added due to typical audible frequency range of adults. **In-depth information about the THD assessment of the Achelous MEMS speaker is available in <https://athena.usound.com/knowledge/>**

**GROUP DELAY**

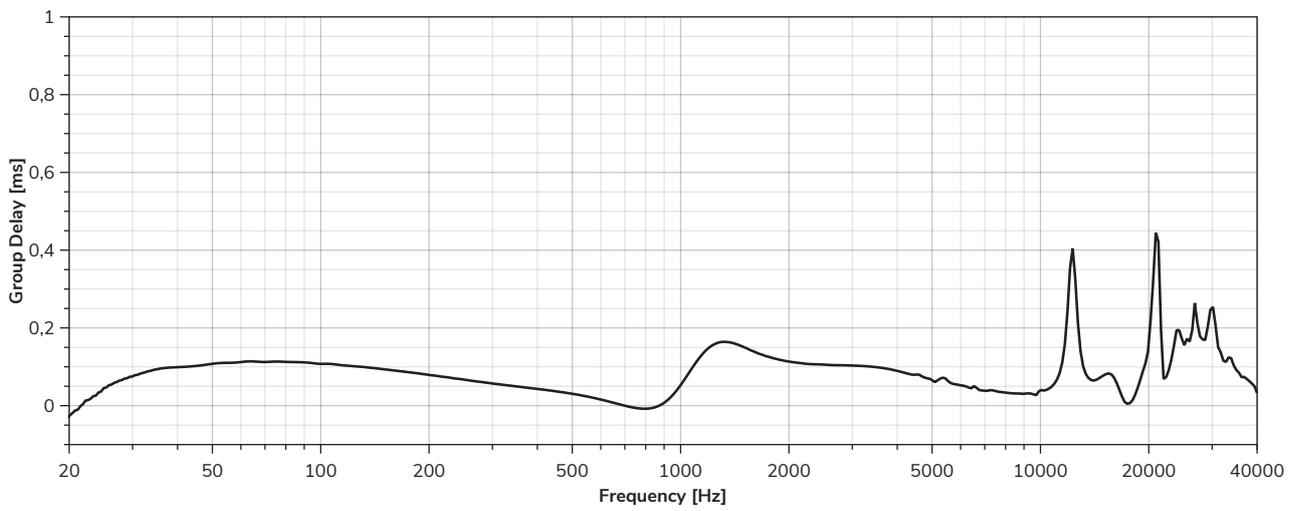


Figure 9: Group delay

**IMPULSE RESPONSE**

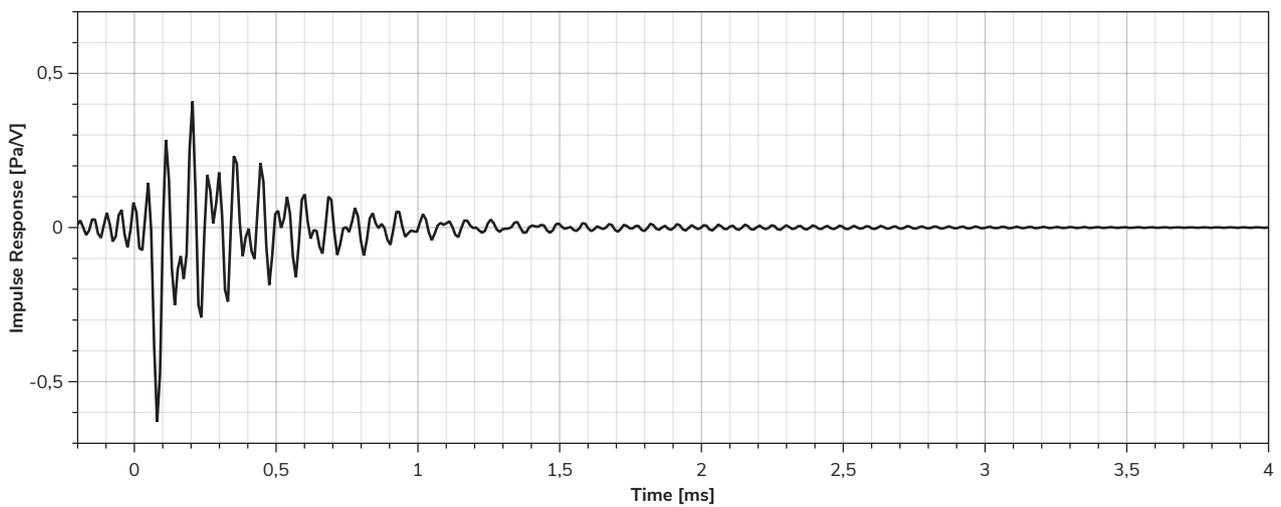


Figure 10: Impulse response, measured @ 15V<sub>p</sub>; sampling frequency of 96 kHz

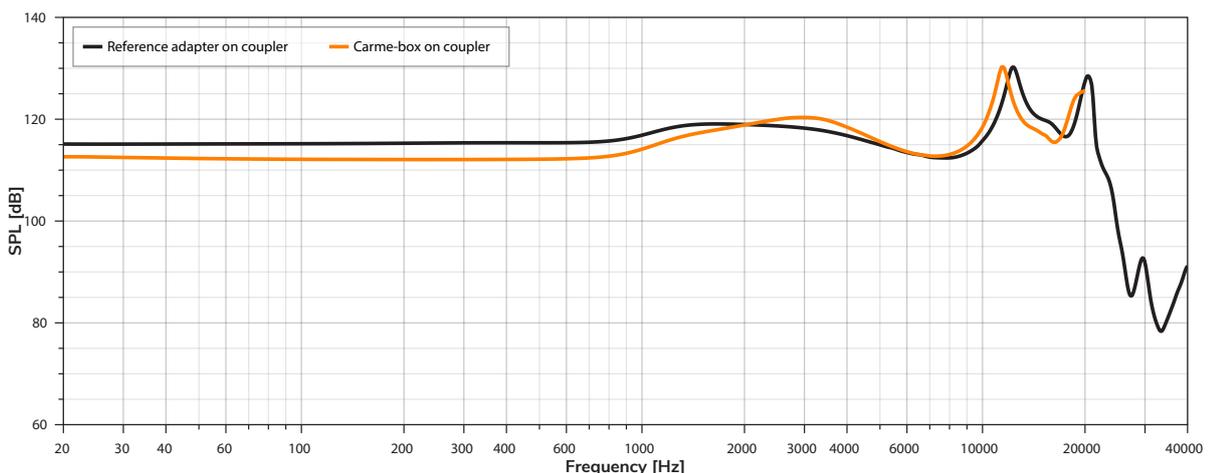
**ACOUSTIC PERFORMANCE USING THE CARME TEST BOX ON COUPLER**

The test box Carme is available to analyse the performance of Achelous MEMS speakers. With a back volume of 100 mm<sup>3</sup>, Carme provides the necessary sealing to avoid an acoustic short circuit and offers a convenient way to connect Achelous to USound's linear amplifier, Amalthea.

To set up the Carme test box, unscrew and separate the PCB from the shell. Remove the housing gasket and place the MEMS speaker 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. To obtain the measurements below, a gasket should be added on the front surface of Carme the box. The Carme box should be placed on the core part of the coupler without the ear mould adaptor.



**Figure 11: Positive input (+) blue and negative input (-) green. The colour coding matches the outputs of Amalthea**



**Figure 12: Achelous SPL measurement in the Carme test box on the coupler**

## HANDLING

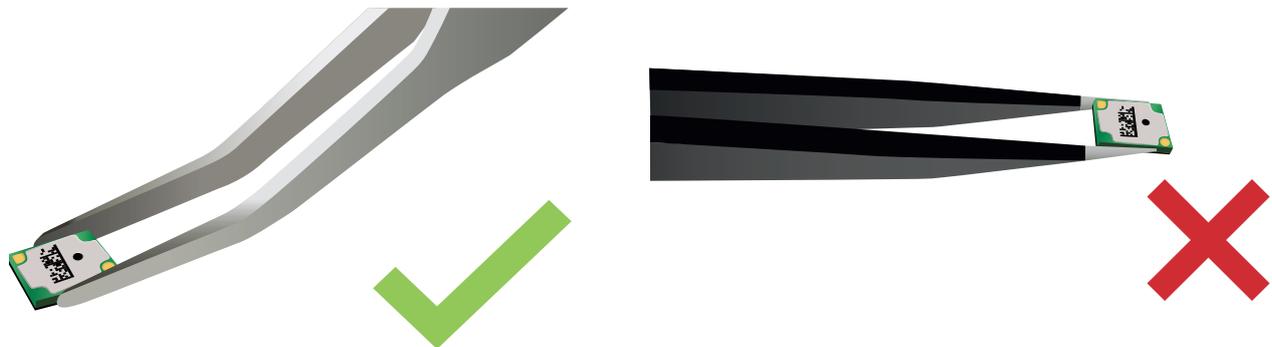
### GENERAL

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 grab the speakers from the sides with blunt curved tweezers and avoid touching the membrane in any case 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 13:** Left: Recommended tweezers type. Right: Not recommended tweezers 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 touch with the application at front side and back side of the speaker.

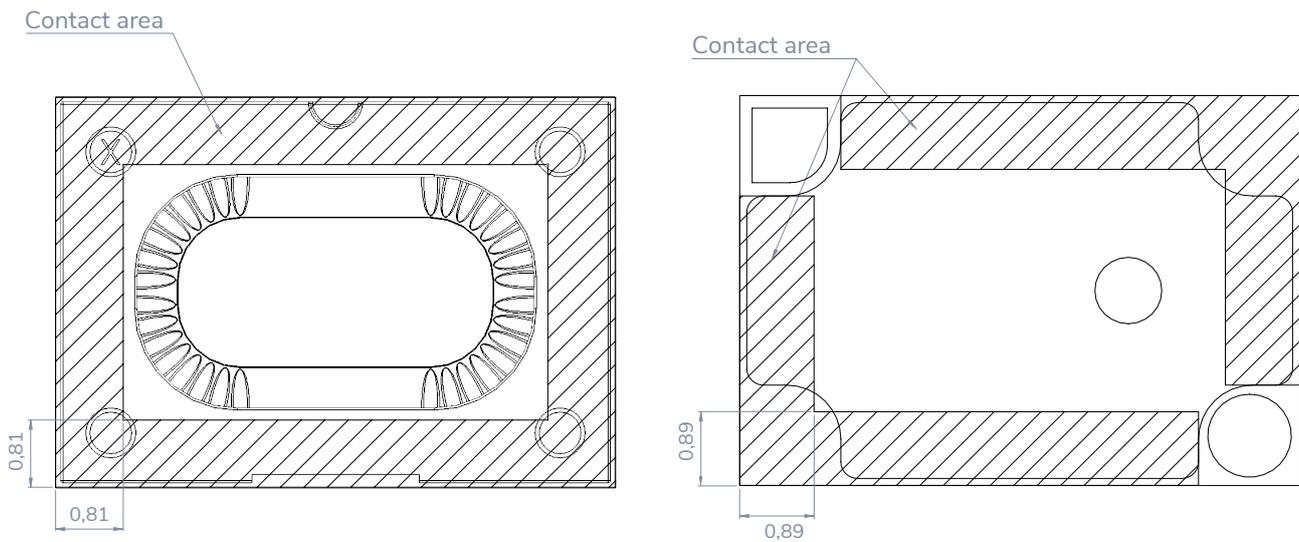


Figure 14: Recommended contact surfaces at back side (right) and front side (left) of the MEMS speaker

## 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.

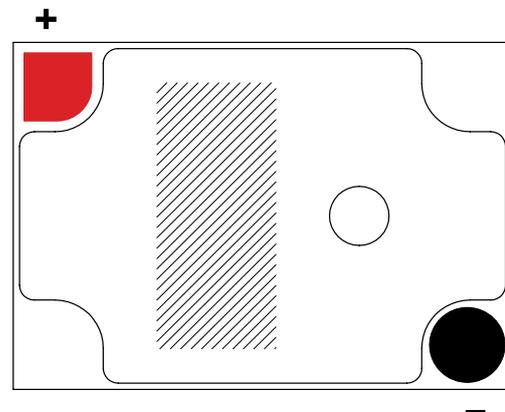


Figure 15: Electrical connections of speaker back side

## LABELLING

Each speaker is equipped with an 8x18 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: 0291024022

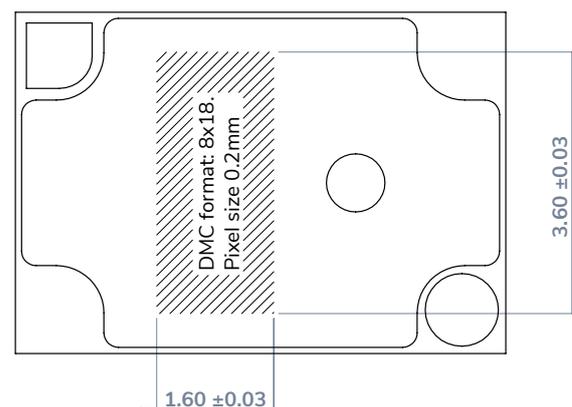


Figure 16: DMC at speaker backside

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

**PACKAGING**

DEEP DRAWN TRAY  
 SIZE : 322 X 136 X 11  
 Thickness: 0.5 mm  
 QTY 150 PCS

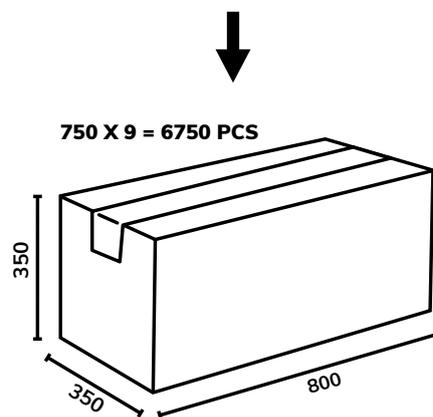
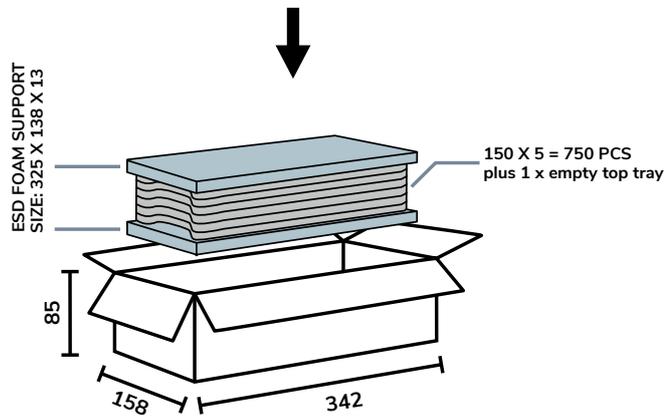
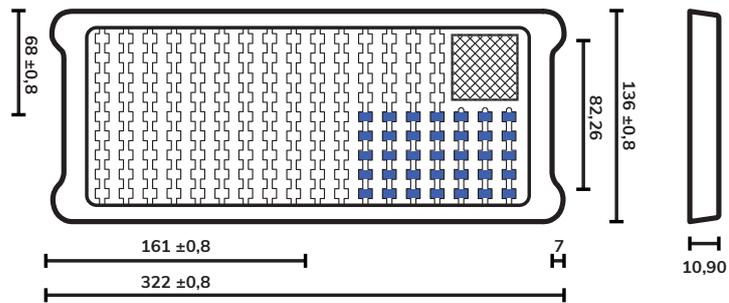


Figure 17: Packaging in tray and carton

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