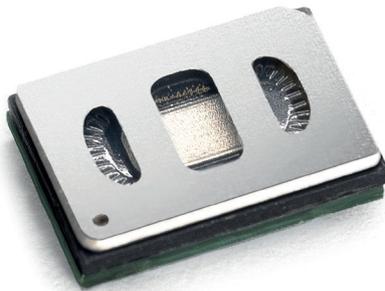


# MEMS SPEAKERS

ADAP UT-P2023 | DATASHEET

U))) SOUND



Adap UT-P2023 MEMS speakers are ideal for free-field audio solutions such as wearables. Due to its small size and low weight, Adap UT-P2023 offers maximum flexibility for outstanding design approaches. Providing a wide bandwidth, it enables high-res audio applications. Adap UT-P2023 produces a tangible, clear, and rich sound that immerses the listener into their personal audio environment.

## FEATURES

- Enables modern, lightweight and ergonomic designs for sophisticated wearables
- Seamlessly integrates into acoustic devices for everyday use
- Extends battery life due to the speaker's low power consumption
- Enhanced cover for handling protection
- Competitive sound pressure level
- No magnetic field
- Low heat generation

## APPLICATIONS

Adap UT-P2023 speakers can be used for free-field audio systems as well as wearables. For 2-way earphones Adap UT-P2023 speakers are suitable as tweeters.

## **CONTENT**

|                                  |           |
|----------------------------------|-----------|
| <b>SPECIFICATIONS</b>            | <b>3</b>  |
| <b>MECHANICAL DIMENSIONS</b>     | <b>4</b>  |
| <b>FORCE ON SPEAKER</b>          | <b>5</b>  |
| <b>TEST CONDITIONS</b>           | <b>6</b>  |
| <b>REFERENCE DRIVING CIRCUIT</b> | <b>7</b>  |
| <b>ACOUSTIC PERFORMANCE</b>      | <b>8</b>  |
| <b>HANDLING</b>                  | <b>11</b> |
| <b>INTEGRATION</b>               | <b>12</b> |
| <b>SPEAKER GASKETS</b>           | <b>13</b> |
| <b>CONNECTIVITY</b>              | <b>14</b> |
| <b>LABELLING</b>                 | <b>14</b> |
| <b>PACKAGING</b>                 | <b>15</b> |

## **REVISION HISTORY**

February 2021: Release

May 2021: Capacity value changed, page 3; speaker gasket information added, page 13

## SPECIFICATIONS

| General acoustics  |                    |     |      |
|--|--------------------|-----|------|
| $f_{res} @ 15 V_p$                                       | [kHz]              | 2.9 | ±15% |
| $Q @ f_{res} / 15 V_p$                                   | [-]                | 0.7 |      |
| Effective membrane surface – $S_D$                       | [mm <sup>2</sup> ] | 12  |      |
| Equivalent volume – $V_{AS}$                             | [mm <sup>3</sup> ] | 40  |      |
| Front volume inside speaker                              | [mm <sup>3</sup> ] | 5.6 |      |
| Back volume inside speaker                               | [mm <sup>3</sup> ] | 20  |      |
| Acoustics in baffle (IEC 60268-5)                        |                    |     |      |
| SPL @ 1 kHz / 15 $V_p$                                   | [dB]               | 53  | ±3.0 |
| SPL @ 4 kHz / 15 $V_p$                                   | [dB]               | 71  | ±3.0 |
| SPL @ 10 kHz / 15 $V_p$                                  | [dB]               | 76  | ±3.0 |
| SPL @ 1 kHz / 5 $V_p$                                    | [dB]               | 43  | ±3.0 |
| SPL @ 4 kHz / 5 $V_p$                                    | [dB]               | 60  | ±3.0 |
| SPL @ 10 kHz / 5 $V_p$                                   | [dB]               | 65  | ±3.0 |
| THD @ 1 kHz / 5 $V_p$                                    | [%]                | 16  | +8   |
| THD @ 4 kHz / 5 $V_p$                                    | [%]                | 5   | +3   |
| THD @ 10 kHz / 5 $V_p$                                   | [%]                | 4   | +3   |
| Electronics  |                    |     |      |
| Capacity   | [nF]               | 26  | ±5   |
| 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 IEC noise (60268-1) incl. high pass @ 2 kHz @ 60 dB | [mW]               | 46  |      |

\*Power consumption measured with the reference driving circuit, shown on page 7; Supply voltage: 3.6 V.

## MECHANICAL DIMENSIONS

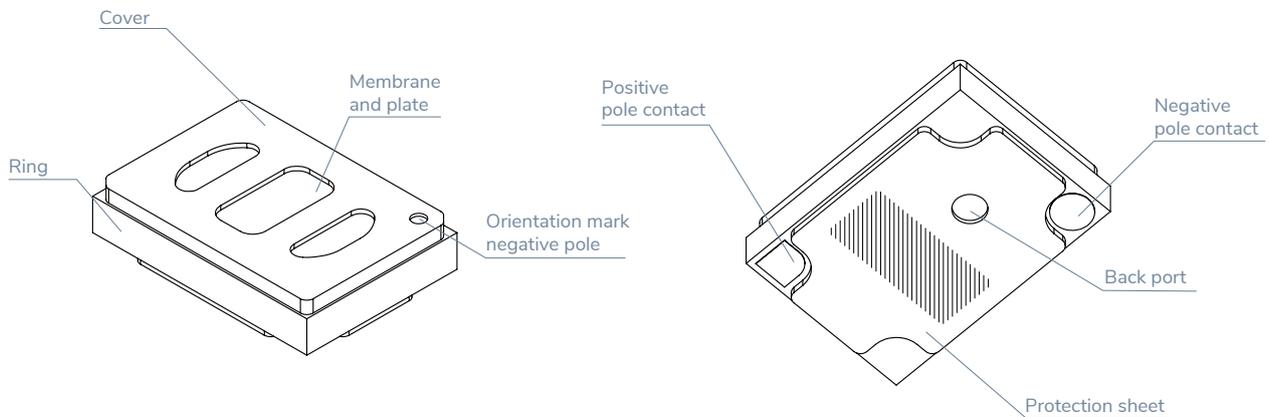


Figure 1: Mechanical drawings: perspective view

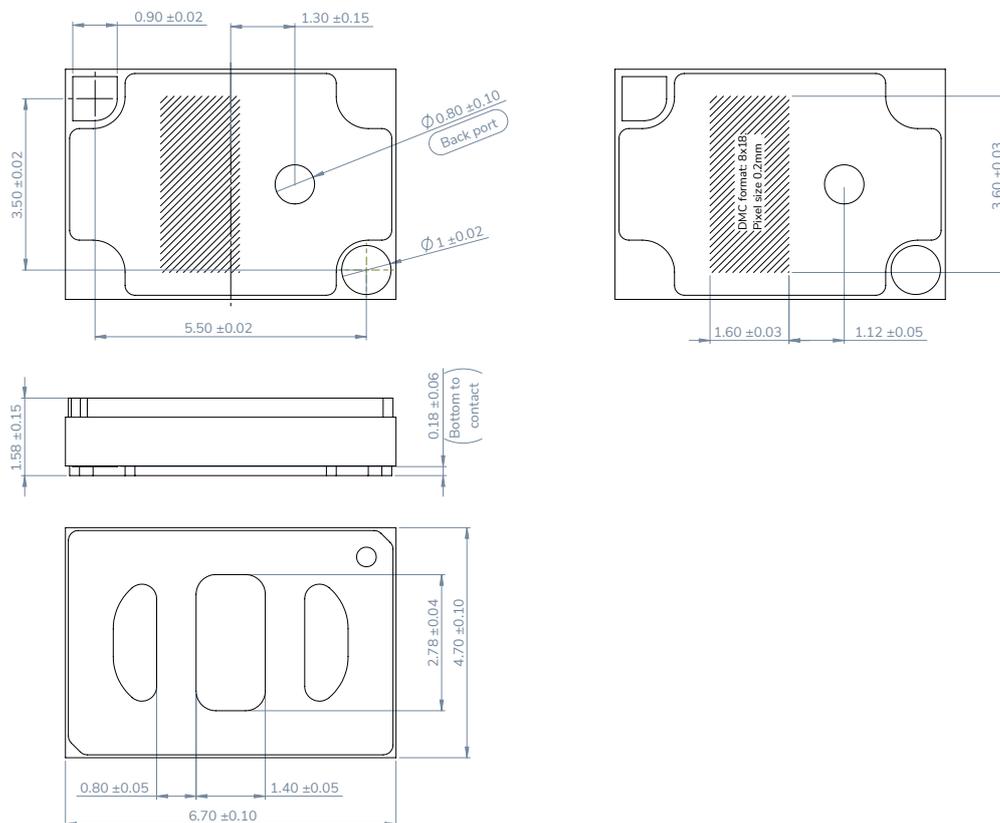


Figure 2: Mechanical drawings: top/down/side view

| Mechanics                  |                    |                  |
|----------------------------|--------------------|------------------|
| Size                       | [mm]               | 6.7 x 4.7 x 1.58 |
| Total speaker weight       | [mg]               | 80               |
| Total speaker cubic volume | [mm <sup>3</sup> ] | 50               |

## 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                           |

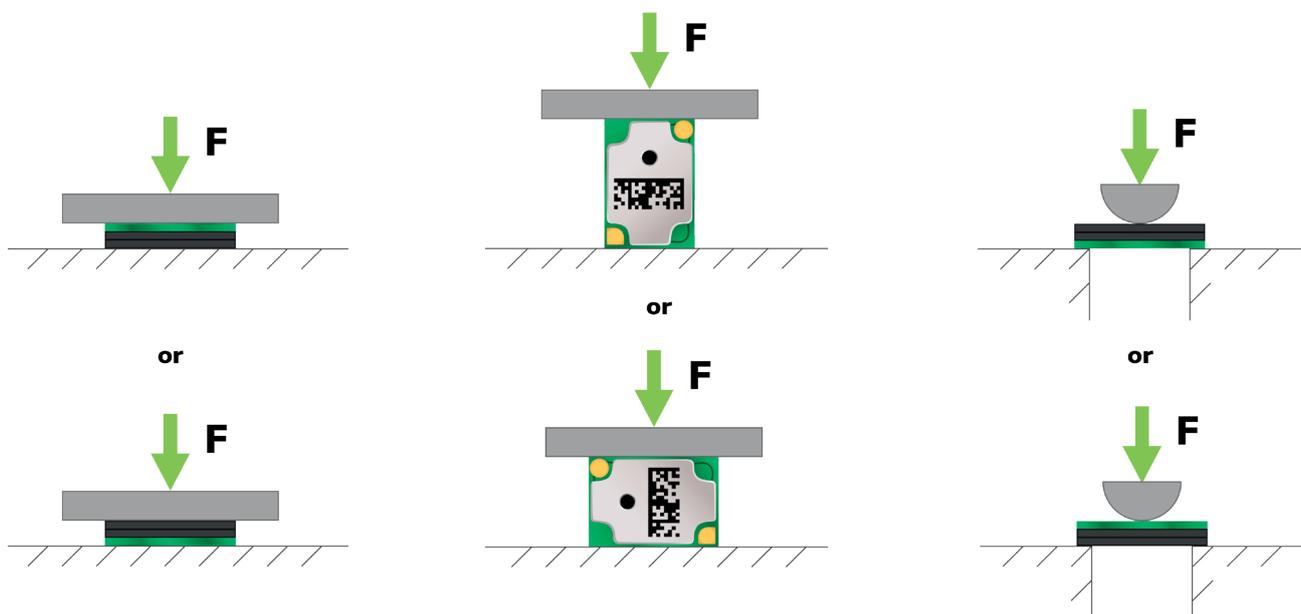


Figure 3: Left: front face compression, centre: side face compression, right: 3-point bending

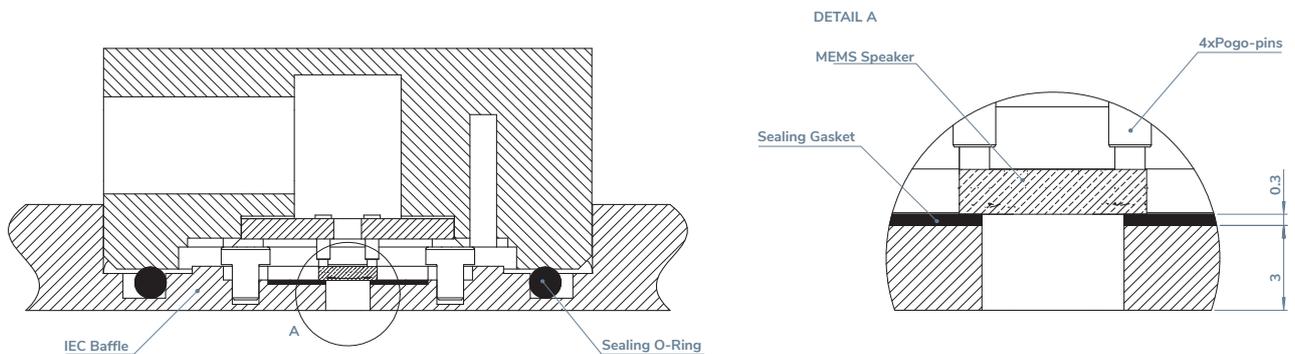
# TEST CONDITIONS

## 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)          |

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

## BAFFLE MEASUREMENT ADAPTER

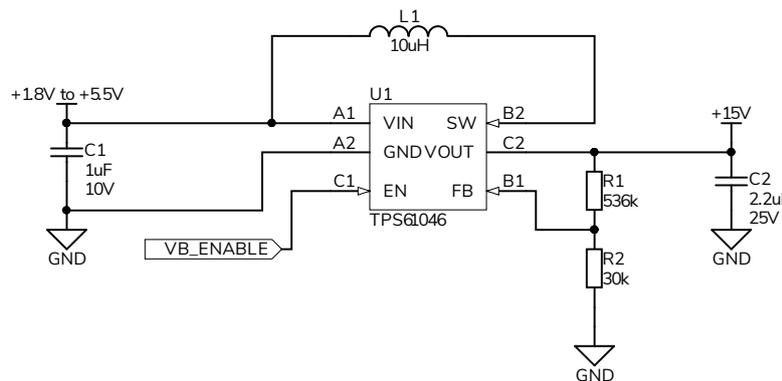


**Figure 4: The outlet through the baffle for the speaker has the same shape as the inside of the speaker cover**

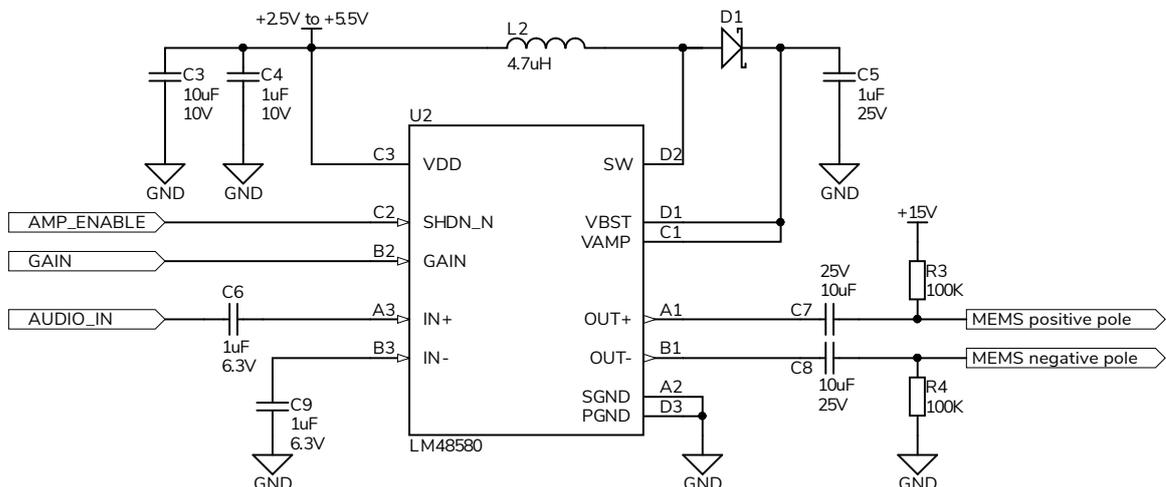
**REFERENCE DRIVING CIRCUIT**

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<sub>DC</sub> 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 (IEC 60268-5)

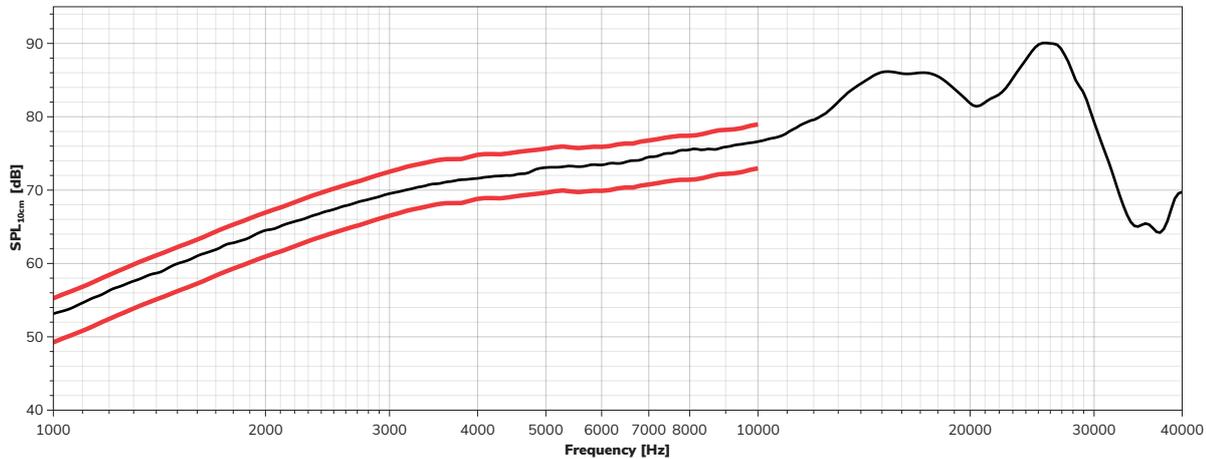


Figure 7: SPL @ 15 V<sub>p</sub> drive\*

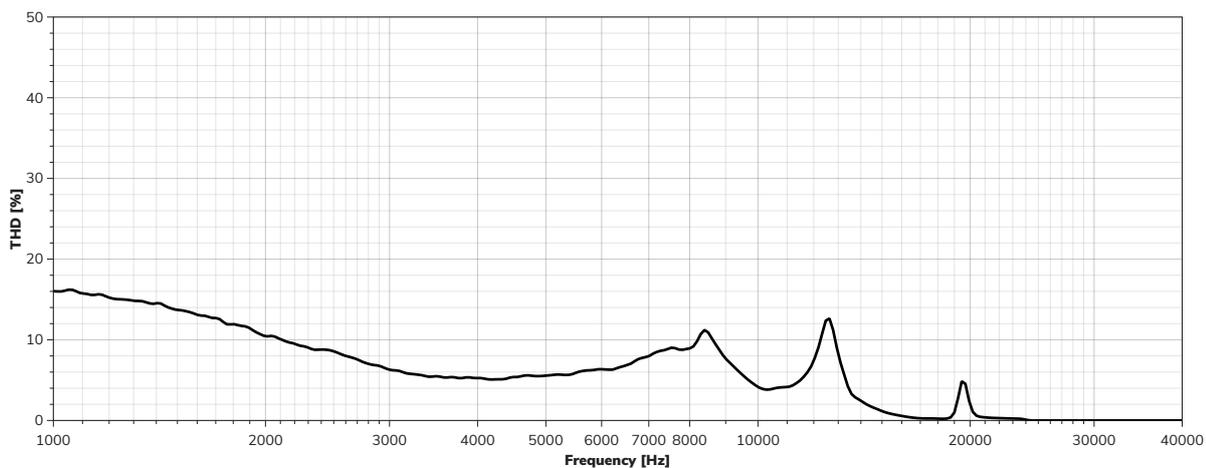
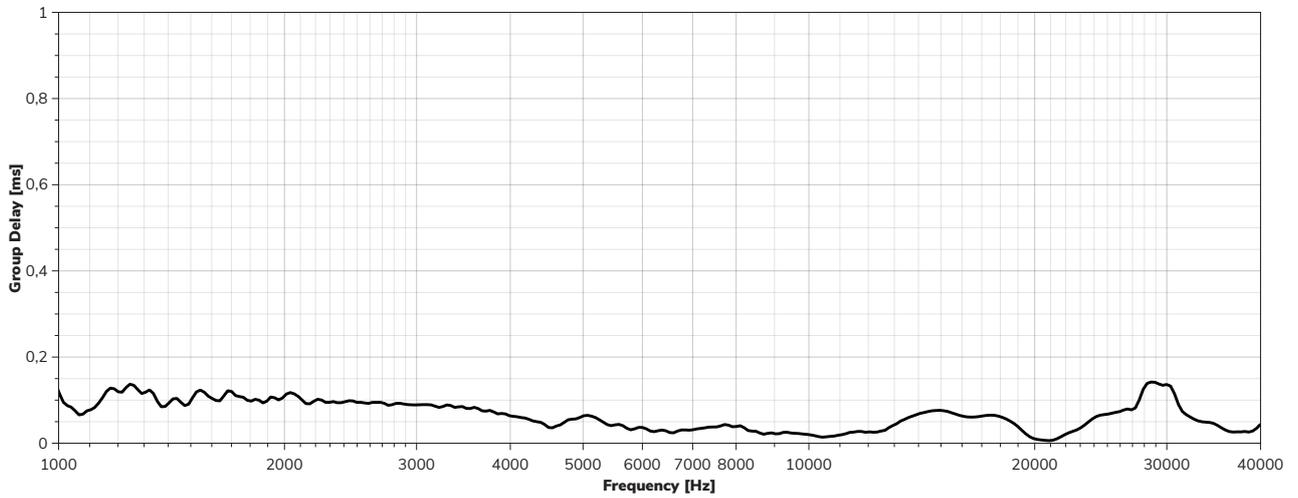


Figure 8: THD 60 dB SPL @ 4 kHz, corresponds to 5 V<sub>p</sub>

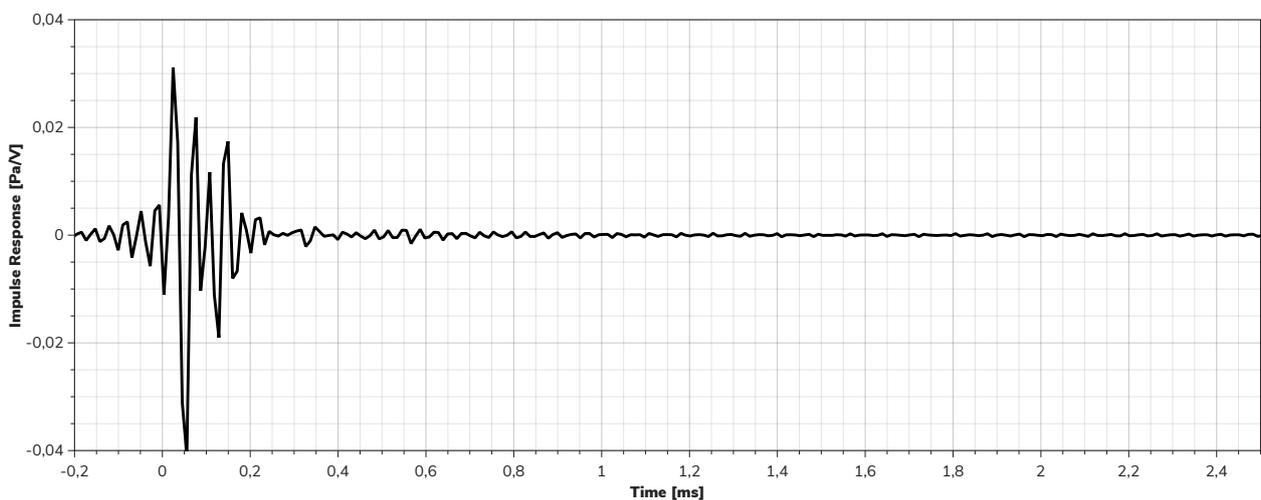
\*Red lines in figure 7 indicate the limits. Test limits are used to establish incoming inspection acceptance/rejection criteria, correlation of test equipment with USound is also a requirement for elimination of equipment and test method variation.

**GROUP DELAY**



**Figure 9:** Group delay; sampling frequency 96 kHz.  
Time delay between speaker and microphone compensated.

**IMPULSE RESPONSE**



**Figure 10:** Impulse response; sampling frequency 96 kHz.  
Time delay between speaker and microphone compensated.

**ACOUSTIC PERFORMANCE USING THE CARME UJ-R1020/UJ-R1030 TEST BOX IN FREE FIELD**

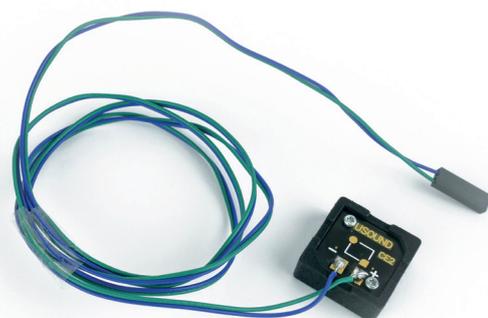
The speaker test box ‘Carme’ is available to analyse the performance of Adap UT-P2023 MEMS speakers. With a back volume of 100 mm<sup>3</sup>, Carme provides the necessary sealing to avoid an acoustic short circuit and offers a convenient way to connect Adap UT-P2023 to USound’s amplifiers. Two versions of Carme are available:

- Carme UJ-R1020 has the proper electrical connection to combine it with the linear Amplifier Amalthea UA-R3010
- Carme UJ-R1030 has the proper electrical connection to combine it with the USound’s evaluation board Helike UA-E3010

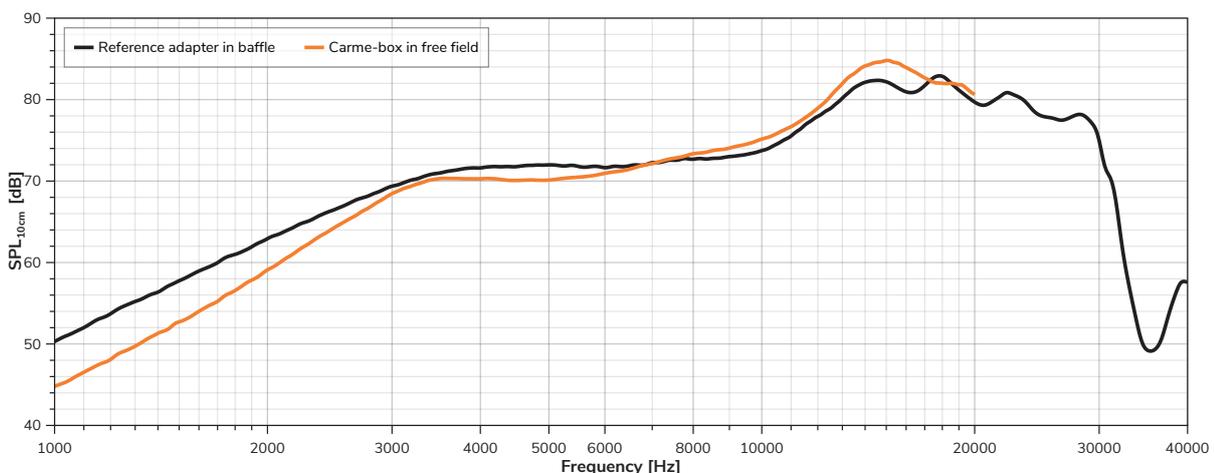
To set up the Carme test box, unscrew and separate the PCB from the shell. Remove the housing gasket and place the MEMS speaker inside the box with the contact side up. Place the PCB by taking care to match the orientation marks with those on the speaker. Tighten the screws for proper sealing. Using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



**Figure 11: Carme UJ-R1020 for Amalthea UA-R3010. The colour coding matches the outputs of Amalthea UA-R3010**



**Figure 12: Carme UJ-R1030 for Helike UA-E3010**



**Figure 13: Adap UT-P2023 SPL measurement in the Carme UJ-R1020/UJ-R1030 test box (10 cm) in free field**

## 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.

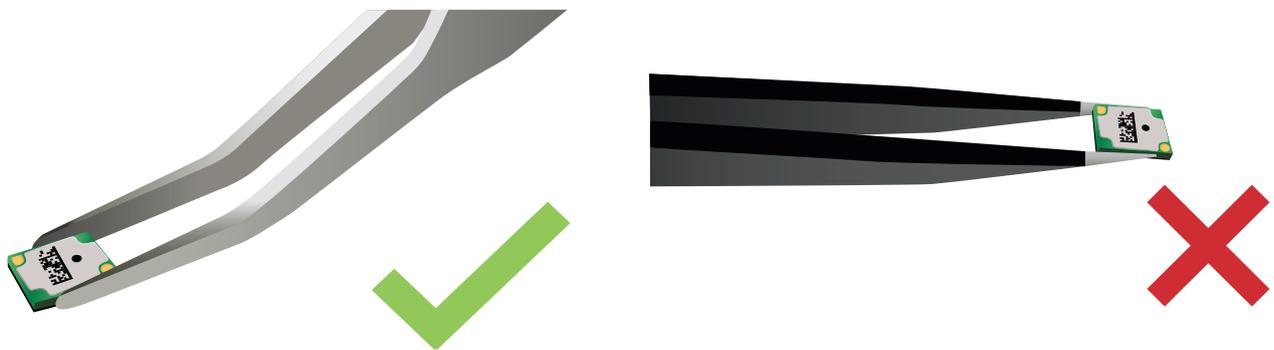


Figure 14: Left: Recommended tweezers type. Right: Not recommended tweezers type

## 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 contact with the application at front side and back side of the speaker.

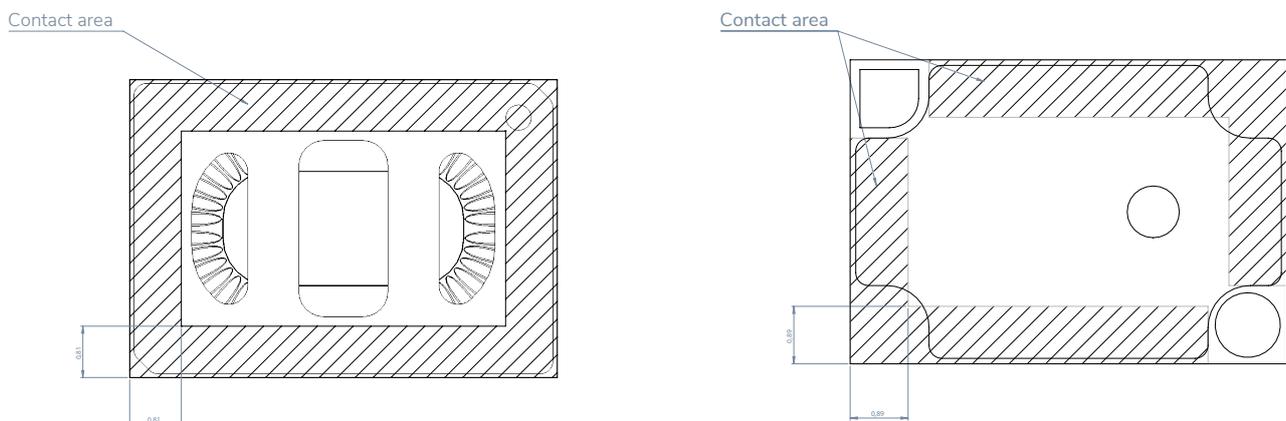


Figure 15: Recommended contact surfaces at the front side (left) and back side (right) of MEMS speaker

## 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                            | <p>Suitable for prototyping</p> <p>The speaker needs to be pushed on the gasket in order to be sealed, some mechanical tolerance can be absorbed.</p> <p>Main application is prototyping and evaluation, where the speaker can be exchanged.</p> | <p>Suitable for mass production</p> <p>The speaker does not need to be pressed against the gasket; sticking it to the gasket during assembly is enough.</p> <p>Main application is mass production where the speaker is mounted permanently. Disassembly will not be possible.</p> |
| Drawings   |  |  |

## 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.

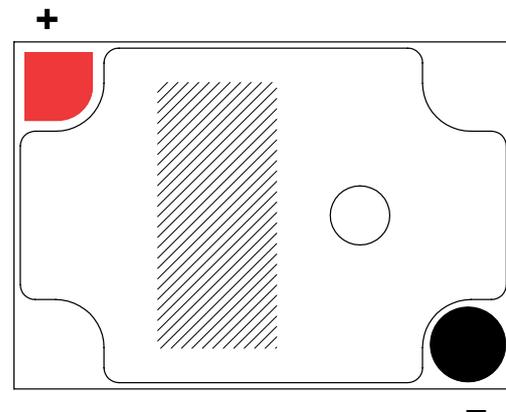


Figure 16: Electrical connections of the speaker back side

## LABELLING

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

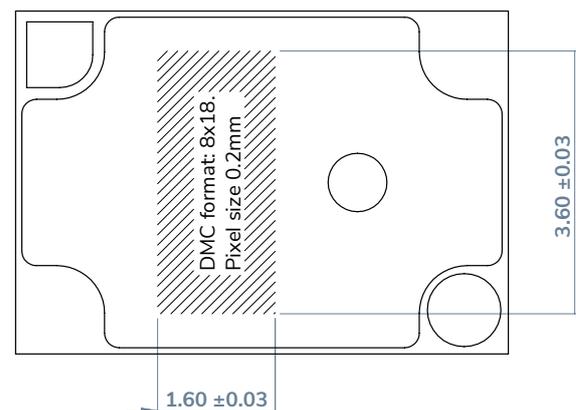


Figure 17: DMC at speaker backside

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

PACKAGING

Thickness: 0.5 mm  
QTY 150 PCS

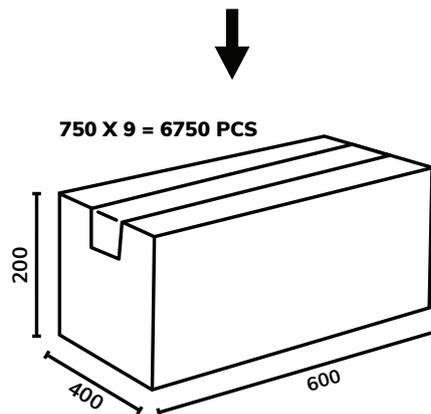
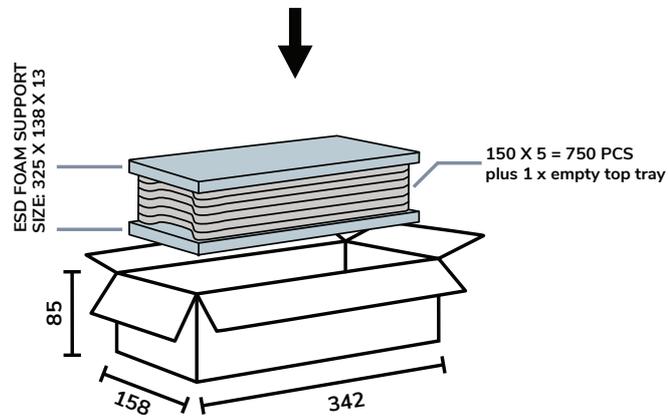
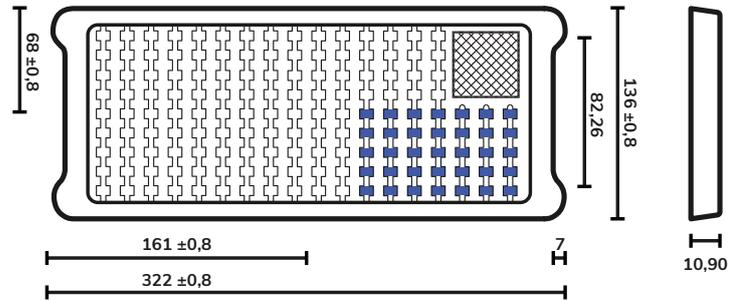


Figure 18: Packaging in tray and carton

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