## **MEMS SPEAKER**

# U)))SOUND

CONAMARA UA-C0503-3T DATASHEET



The 5 mm Conamara UA-C0503-3T is the ideal tweeter for a wide range of audio products, such as in-ear wired earphones and true wireless stereo earbuds (TWS). Its state-of-the-art MEMS technology allows reaching maximum efficiency, covering the high frequency range at the smallest speaker thickness available on the market. Due to its round form factor, low weight, and thickness, Conamara UA-C0503-3T can be easily integrated into miniaturized audio products.

#### **FEATURES**

- Extended bandwidth frequency range (2 kHz – 80 kHz)
- Designed for Hi-Res audio
- Ultra-slim form factor: Ø 5.0 x 1.48 mm
- Low temperature reflow solderable (200°C)
- IPX8 waterproof
- No magnetic field
- Negligible heat generation

### **APPLICATIONS**

Conamara UA-C0503-3T is the ideal tweeter for a wide variety of applications such as wired earphones, true wireless systems (TWS), in ear monitors and ultrasonic applications.

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### **REVISION HISTORY**

April 2024: Release
May 2024: Updated pages 4; 7
June 2024: Soldering information added page 8, 10
September 2024: Baffle measurements added

### SPECIFICATIONS

Nominal driving conditions, if not otherwise noted: 2.5  $V_{_{RMS}}$  (3.5  $V_{_{P}}\!)$  +10  $V_{_{DC}}$ 

| General Acoustics                    |       |     |      |
|--------------------------------------|-------|-----|------|
| f <sub>res</sub>                     | [kHz] | 5.2 | ±10% |
| Q-factor                             | [-]   | 2.5 |      |
| Effective membrane surface – $S_{D}$ | [mm²] | 9.1 |      |
| Equivalent volume – V <sub>AS</sub>  | [mm³] | 8   |      |
| Internal back volume of the speaker  | [mm³] | 6   |      |

| Acoustics in coupler (IEC 60318-4)   |      |     |      |
|--|------|-----|------|
| SPL @ 1 kHz / 2.5 V $_{\rm RMS}$ (3.5 V $_{\rm P}$ ) +10 V $_{\rm DC}$         | [dB] | 94  | ±3   |
| SPL @ 5 kHz / 2.5 $V_{_{RMS}}$ (3.5 $V_{_{P}}$ ) +10 $V_{_{DC}}$               | [dB] | 110 | ±3   |
| SPL @ 8 kHz / 2.5 $V_{_{\rm RMS}}$ (3.5 $V_{_{\rm P}}$ ) +10 $V_{_{ m DC}}$    | [dB] | 105 | ±3   |
| SPL @ 1 kHz / 7.1 V $_{\rm RMS}$ (10 V $_{\rm p}$ ) +10 V $_{\rm DC}$          | [dB] | 103 | ±3   |
| SPL @ 5 kHz / 7.1 V $_{\rm RMS}$ (10 V $_{\rm p}$ ) +10 V $_{\rm DC}$          | [dB] | 119 | ±3   |
| SPL @ 8 kHz / 7.1 V $_{\rm RMS}$ (10 V $_{\rm p}$ ) +10 V $_{\rm DC}$          | [dB] | 114 | ±3   |
| SPL @ 1 kHz / 9.5 $V_{_{RMS}}$ (13.5 $V_{_{P}}$ ) +10 $V_{_{DC}}$              | [dB] | 106 | ±3   |
| SPL @ 5 kHz / 9.5 $V_{_{RMS}}$ (13.5 $V_{_{P}}$ ) +10 $V_{_{DC}}$              | [dB] | 121 | ±3   |
| SPL @ 8 kHz / 9.5 $V_{_{RMS}}$ (13.5 $V_{_{P}}$ ) +10 $V_{_{DC}}$              | [dB] | 117 | ±3   |
| THD @ 1 kHz / 2.5 $\rm V_{\rm RMS}$ (3.5 $\rm V_{\rm p})$ +10 $\rm V_{\rm DC}$ | [%]  | 1.4 | +0.8 |
| THD @ 5 kHz / 2.5 $\rm V_{\rm RMS}$ (3.5 $\rm V_{\rm p})$ +10 $\rm V_{\rm DC}$ | [%]  | 0.7 | +0.5 |
| THD @ 8 kHz / 2.5 V $_{\rm RMS}$ (3.5 V $_{\rm P}$ ) +10 V $_{\rm DC}$         | [%]  | 0.4 | +0.3 |

| Electronics                             |      |     |      |
|---|------|-----|------|
| Capacitance (with LCR-Meter at 1V/1kHz) | [nF] | 9.0 | ±2.0 |
| SPL @ 1 kHz / 1 mW                      | [dB] | 99  | ±3   |
| SPL @ 5 kHz / 1 mW                      | [dB] | 106 | ±3   |

| Operating conditions            |                   |      |  |
|---------------------------------|-------------------|------|--|
| Maximum AC voltage              | [V <sub>P</sub> ] | 13.5 |  |
| DC voltage                      | [V]               | 10   |  |
| Upper operating frequency limit | [kHz]             | 80   |  |

| Dimensions           |      |       |       |
|----------------------|------|-------|-------|
| Diameter             | [mm] | Ø 5.0 | ±0.1  |
| Thickness            | [mm] | 1.48  | ±0.15 |
| Total speaker weight | [mg] | 75    | ±10%  |

### **MECHANICAL DIMENSIONS**







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

### **TEST CONDITIONS**

| General                         |  |
|---------------------------------|--|
| Measurement system              | Audio Precision APx  |
| Measurement signal              | Exp. Sweep   |
| Voltage level $V_{AC} + V_{DC}$ | $2.5 V_{_{RMS}} (3.5 V_{_{P}}) + 10 V_{_{DC}} / / 9.5 V_{_{RMS}} (13.5 V_{_{P}}) + 10 V_{_{DC}}$ |
| Applied back volume             | Open (infinite)  |

| Coupler (IEC 60318-4)    |                      |
|--------------------------|----------------------|
| Coupler type             | IEC 60318-4 ('711')  |
| Coupler volume           | 1.26 cm <sup>3</sup> |
| Connection tube length   | 1.5 mm               |
| Connection tube diameter | 3.0 mm               |
| Microphone               | GRAS 43AC            |



Figure 3: Coupler adapter cross-section. The speaker adapter is directly screwed onto the coupler; the ear mold adapter is not used. The outlet for the speaker is round with a diameter of 3 mm and length of 1.5 mm.

USound offers a speaker evaluation kit (Carme kit UJ-E1040C05) to replicate the coupler adapter design above. The datasheet measurements can be reproduced by using Carme kit.

### **ACOUSTIC PERFORMANCE**

#### ACOUSTIC PERFORMANCE IN COUPLER



Figure 4: SPL at 2  $V_{RMS}$  (3.5  $V_{P}$ ) + 10  $V_{DC}$  drive and at 9.5  $V_{RMS}$  (13.5  $V_{P}$ ) + 10  $V_{DC}$  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 5: THD at 2.5  $V_{RMS}$  (3.5  $V_{p}$ ) + 10  $V_{DC}$  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).



#### **ACOUSTIC PERFORMANCE IN BAFFLE**

Figure 6: SPL at 9.5 V  $_{\rm RMS}$  (13.5 V  $_{\rm P})$  + 10 V  $_{\rm DC}$  drive, measured with the standard baffle (IEC 60268-5).



Figure 7: THD at 2.5  $V_{RMS}$  (3.5  $V_{p}$ ) + 10  $V_{DC}$  drive, measured with the standard baffle (IEC 60268-5).



### CONNECTIVITY

The speaker is driven by applying a voltage between the (+) and the (-) contacts. The bigger pad corresponds to the negative input, the smaller pad to the positive (Figure 1). The AC and DC voltage needs to be applied between (+) and (-) with the (+) being at the higher potential. The recommended DC level is  $10 V_{pc}$ .

A positive voltage on the positive pad will result in the membrane moving up (away from the pads).

The default driving conditions for MEMS speakers require a  $10 V_{DC}$  bias. USound Conamara MEMS speakers, however, can be driven without DC bias with minor impacts on the acoustic and electrical performance. Additionally, it results in a 20% reduction in the footprint of external components needed for Tarvos 1.0 linear ASIC amplifier. For more information, please get in contact with USound's sales team for support (sales@usound.com).

#### **REFERENCE DRIVING CIRCUIT**

Tarvos 1.0 UC-P3010 is the recommended linear audio amplifier for driving USound MEMS speakers. The reference driving circuit and layout design guidelines are included in the Tarvos 1.0 datasheet. Designed for capacitive loads, Tarvos 1.0 is the ideal solution for integrating USound MEMS speakers and other piezo transducers in a wide range of audio products.

### HANDLING

#### GENERAL

MEMS devices consist of silicon structures and should be handled with care. Bending of the MEMS speakers must be avoided during the assembly process to avoid any damages.

#### TWEEZERS

It is recommended to gently grip the speakers from the sides with blunt curved tweezers (Figure 8). Touching the MEMS chip from the back side needs to be avoided. Using sharp tweezers must be avoided.



Figure 8: Left: not recommended tweezer type. Right: recommended tweezer type.



### HAND SOLDERING

Improper soldering of MEMS speakers at high temperatures can potentially damage the component. Apply soldering iron only on the electrical pads on the bottom side of the speaker during the soldering process. It is recommended to follow the standard IPC J-STD-001 "Requirements for Soldered Electrical and Electronic Assemblies." For inspection, it's suggested to follow IPC-A-610G.

#### RECOMMENDATIONS

| Туре                  | Recommended Parameters   | Comments                              |
|-----------------------|--|---------------------------------------|
| Soldering Temperature | 340°C (Possible range: 290 - 400°C)  | Adjust with the soldering station     |
| Soldering Time        | 1-2 s (maximum 5 s)  | Keep contact duration short           |
| Soldering Iron Tip    | Weller LT 1S 0.2 mm – 0.4 mm   | Fine solder tip for precise soldering |
| Soldering Station     | JBC DDE 2 Tools  | User preference                       |
| Soldering Wire        | RS-756-884 0.71 mm Lead Free<br>EDSYN SU35100 with Flux<br>EDSYN SSAC2010 0.2 mm Lead Free | Use lead-free soldering wire          |
| Flux                  | Chemtronics CW8100<br>Flux Dispensing Pen  | Avoid excess application              |

#### **REFLOW SOLDERING**

#### **REFLOW SOLDERING PROFILE**

USound's Conamara MEMS speakers allow low temperature reflow soldering with a peak temperature of 200°C with negligible change of performance. The reflow profile used for this classification is specified in the table below and in Figure 9.



Figure 9: Reflow soldering profile.

| Step               |      | Temperature  |     | Duration                |
|--------------------|------|--|-----|-------------------------|
| Preheat            | [°C] | T <sub>Smin</sub> = 110<br>T <sub>Smax</sub> = 145 | [s] | t <sub>smax</sub> = 60  |
| Liquidous          | [°C] | T <sub>Lmax</sub> = 157                            | [s] | t <sub>Lmax</sub> = 120 |
| Peak               | [°C] | T <sub>Pmax</sub> = 200                            | [s] | t <sub>Pmax</sub> = 20  |
| Time 25 °C to Peak | [°C] | -  | [s] | t <sub>max</sub> = 240  |

#### HOST PCB DESIGN GUIDELINES FOR REFLOW SOLDERING

To execute the reflow soldering process with negligible performance change we recommend adhering to the following guidelines when designing the host PCB. The dimensions of the speaker's connection pads for the host PCB are shown in **Figure 10**. For matching the rotational orientation of the speaker to the host PCB, the orientation marker shown in the MARKING section can be utilized.



# Figure 10: Dimensions and positions of the connection pads and back opening for the speaker on the host PCB

A through-hole with a diameter larger than 1.2 mm must be placed on the host PCB fully within the confinements of the 2.4 mm-back opening of the speaker. To guarantee proper acoustic performance, airtight sealing must be insured around the back opening between the speaker and host PCB.

Avoiding any contamination to enter the opening of the speaker is essential for maintaining the performance and usability of the speaker.

### MARKING

The speaker cover contains a Data Matrix Code (DMC) with a unique ID for each speaker. Additionally, human readable numbers indicate production date and speaker type. Also present on the cover is an orientation marker which marks the center point of the negative connection pad on the bottom side of the speaker.



Figure 11: Front view of the speaker describing the marking.

| Labelling |                    |  |
|-----------|--------------------|--|
| YY        | 2 digits           | Year (00-99)                             |
| WW        | 2 digits           | Calendar week (01-52)                    |
| D         | 1 digit            | Weekday (1-7)                            |
| MM        | 2 digits           | Manufacturing information                |
| Т         | 1 letter           | Speaker type (F: Full range, T: Tweeter) |
| SS        | 2 digits           | Speaker size (06/05: 6/5 mm diameter)    |
| DMC       | 10 digits (ECC200) | Serial number                            |

#### SIMILAR PRODUCTS

| Product Name                          | Description  |
|---------------------------------------|--|
| <u>Conamara</u><br><u>UA-C0603-3T</u> | MEMS tweeter for 2-way speaker solution in wearables and hearables, ultrasonic applications, tweeter, 6 mm diameter. |
| <u>Conamara</u><br><u>UA-C0603-3F</u> | MEMS speaker for wearables and hearables, full-bandwidth, 6 mm diameter.   |

#### **COMPATIBLE PRODUCTS**

| Product Name                               | Description   |
|--|---|
| <u>Amalthea 1.0</u><br><u>UA-R3010</u>     | MEMS speaker array amplifier with a frequency range up to 80 kHz, can drive up to 40 MEMS speakers, including heatsink housing. |
| Carme kit<br>UJ-E1040C05                   | A speaker evaluation kit for testing the acoustic performance of the USound MEMS speaker Conamara 5 mm.                         |
| <u>Tarvos 1.0</u><br><u>UC-P3010</u>       | ASIC linear audio amplifier with analog input to drive the USound MEMS speakers.  |
| Tarvos Evaluation<br>Board 1.0<br>UC-E3010 | Evaluation board for testing key features of the USound ASIC linear audio amplifier.  |

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