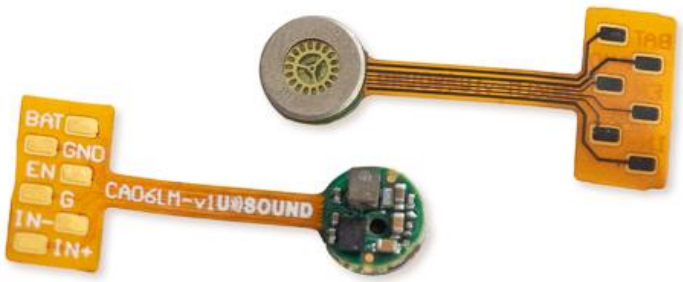
KORE 4.0 UMC-P04C06012F

APPLICATION NOTE



DESCRIPTION

The Kore 4.0 UMC-P04C06012F integrated audio module consists of Conamara full range MEMS speaker 6 mm diameter UA-C0601-2F and Tarvos 1.0 UC-P3010 linear audio amplifier. It is designed to equip TWS earbuds and hearing aids with exceptional audio performance at the smallest form factor.

FEATURES

- Target max SPL: 115 dB @ 1 kHz, 112 dB @ 250 Hz
- Target typical THD (94 dB): 0.35% @ 1 kHz
- Target bandwidth: 20 Hz - 40 kHz
- ASIC amplifier class H with ultra low power consumption
- ASIC audio amplifier with lowest noise and THD, and high rejection of external noise
- ASIC audio amplifier with over-temperature protection
- ASIC audio amplifier with short circuit protection
- E-Fuse memory for default non-volatile user configuration
- Enabling IP68 classification of the end-product
- Optional I2C configuration interface for selectable gain (18 dB, 24 dB or 30 dB), boost voltage and MEMS speaker DC bias

CONTENTS

INTRODUCTION

The integrated audio module Kore 4.0 UMC-P04C06012F enables easy integration in true wireless earbuds or in OTC products. The integrated module consists of the MEMS speaker Conamara UA-C0601-2F and the linear ASIC amplifier Tarvos 1.0 UC-P3010 along with its associated passive circuitry. It features USound patented MEMS and driving technology, achieving an ultra-compact form factor.
The audio module interfaces with audio sources, such as TWS chipsets, through the integrated MEMS speaker audio amplifier Tarvos 1.0 UC-P3010. It is a high-voltage linear audio amplifier with an integrated DC-DC boost converter. The device operates from a 3.6V Li-Ion battery with very low power consumption, ideally for long-lasting earbuds. Audio input is analog, compatible with the analog outputs of the most common Bluetooth Audio SoC.
Control and setup can be optionally provided through an I2C interface.

PRODUCT OVERVIEW

The integrated audio module Kore 4.0 UMC-P04C06012F is designed to provide easy integration into the TWS earbuds or OTC products through the implementation of the driving electronics in one package with the MEMS speaker. The amplifier gets assembled on one side of the PCB, along with its associated circuitry, and the MEMS speaker contacted on the other side by solder reflow process, as Figure 1 shows.

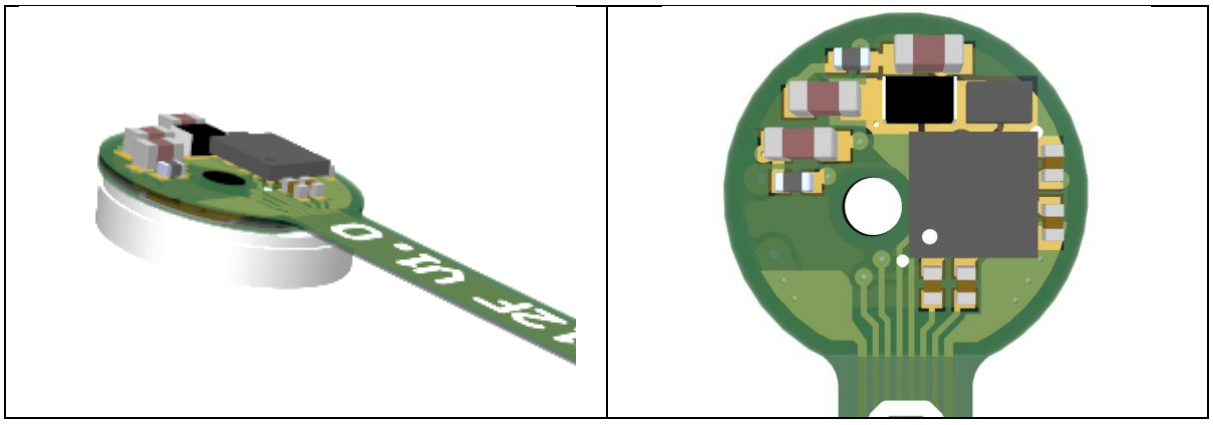


Figure 1. Integrated audio module Kore UMC-P04C06012F with MEMS speaker Conamara UA-C0601-2F on one side of the PCB and driving electronics on the other side.

The audio module reaches a height of only 2.3 mm and an overall maximum diameter of 6 mm. More details about dimensions are shown in

The integrated audio module Kore UMC-P04C06012F can be easily evaluated with a dedicated released design, as it features a standard pitch header connector. Figure 2 shows the actual audio module for only evaluation purposes.

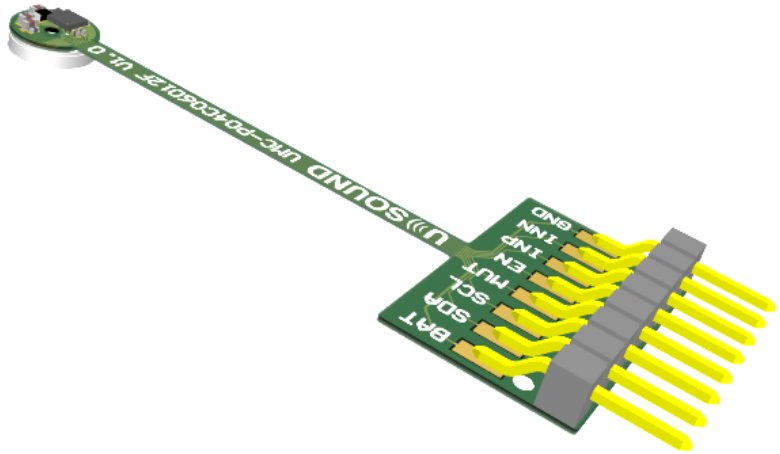


Figure 2. Integrated audio module Kore UMC-P04C06012F with MEMS speaker Conamara UA-C0601-2F (with robust and accessible header connector) for evaluation only

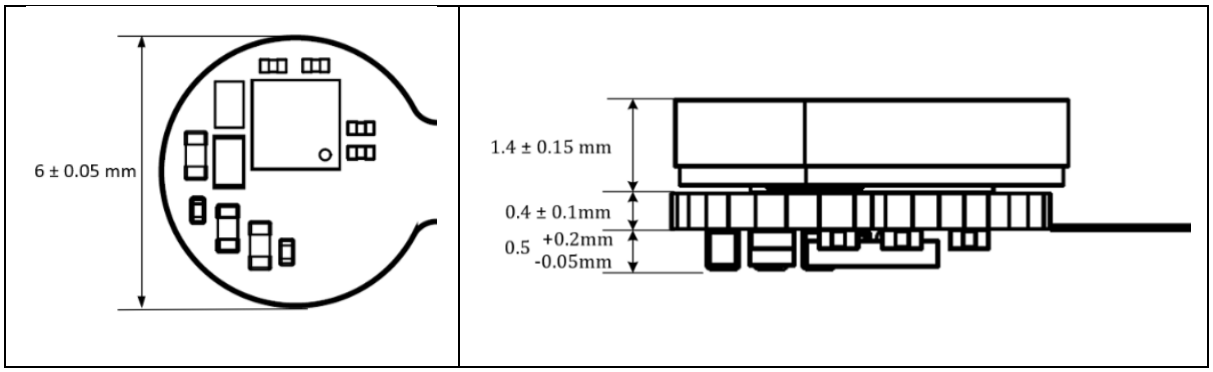


Figure 3. Integrated audio module Kore UMC-P04C06012F - top view (left), front view (right). Total thickness is 2.3 mm.

AUDIO MODULE CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS

Parameter	Min	Max	Unit	Conditions
Junction Temperature		150	˚C	
Storage Temperature	-40	85	˚C	
Storage Temperature, short term		260	˚C	Max 2 min, solder reflow req.
Power supply	-0.3	5.5	V	
ESD – Human Body Model		2	kV	JEDEC JS-001
ESD – Charged Device Model		500	V	JEDEC JS-002
Moisture Sensitivity Level	2			

OPERATING CONDITIONS

Parameter	Min	Typ	Max	Unit	Conditions
Junction Temperature	-20	25	125	˚C	
Ambient Temperature	-20	25	70	˚C	
Power supply	2.7	3.6	4.5	V	

AMPLIFIER DC CHARACTERISTICS

Parameter	Min	Typ	Max	Unit	Conditions
Quiescent operating current			1.2 0.9	mA	V_{AC}=0 V, R=∞, V_{BST}=8 V V_{AC}=0 V, R=∞, V_{BST} off
Quiescent muted current			0.2	mA	MUTE=1 (no pop-click)
Shutdown current			0.5	uA	EN=0
MEMS DC Bias externally added (external RC circuit)	0	10	+V_{BST}	V	5V≤ V_{BST} ≤16V. In steps of 1V
Power consumption			20	mW	V_{AC}=10 V_p (max voltage) @1 kHz
(Including speaker as load)			5.0		V_{AC}=1.5 V_p @ 1 kHz (corresp. to 94 dB@1 kHz SPL)
			5.0		V_{AC}=0.75 V_{rms} IEC 60268-1 noise, crest factor 12 dB (corresp. to 94 dB SPL)
Thermal protection threshold	115	120	125		Triggers -6 dB gain reduction without pop-click
Thermal protection hysteresis	5		10	°C	

AMPLIFIER AC CHARACTERISTICS

Unless otherwise specified, V_{BAT}=3.6 V, T_{AMB}=25° C.

Parameter	Min	Typ	Max	Unit	Conditions
Input voltage			3	V_{pp}	
Input common-mode voltage	0		2	V	
Input resistance	8		320	kΩ	Differential resistance between the input pins INP and INN
Gain	0 1.0		30.1 32.0	dB V/V	Excluding effect of external LPF Programmable settings table
Input Noise A-Weighted, 20Hz-20kHz			2.2	uVrms	GAIN=30dB
			3.2	uVrms	GAIN=24dB
			5.5	uVrms	GAIN=18dB
Signal to Noise Ratio			105	dB	A-Weighted, 20Hz-20kHz, f=1kHz, V_{AC}=30V_{pp}, GAIN=24dB
Total Harmonic Distortion			0.03	%	Fout=1kHz, V_{AC}=30V_{pp}, GAIN=24dB
Common-mode rejection ratio		80		dB	F_{CM}=1kHz, V_{CM}=100mV_{pp}, AIN=24dB
Power supply rejection ratio		80		dB	F_{CM}=1kHz, V_{CM}=100mV_{pp}, AIN=24dB

AUDIO MODULE ELECTRICAL INTERFACE

The audio module interfaces with the audio source through the following inputs:

- Supply:
  - Battery positive terminal (VBAT)
  - Battery negative terminal (GND)
- Enable (full enable/disable)
- Mute (low-power and click and pop suppression)
- Audio signal:
  - Positive Input
  - Negative Input
- Optional I2C control interface (for adjusting amplifier gain, MEMS DC bias and boosted voltage):
  - SDA, I2C data
  - SCL, I2C clock

SPEAKER ACOUSTIC PERFORMANCE

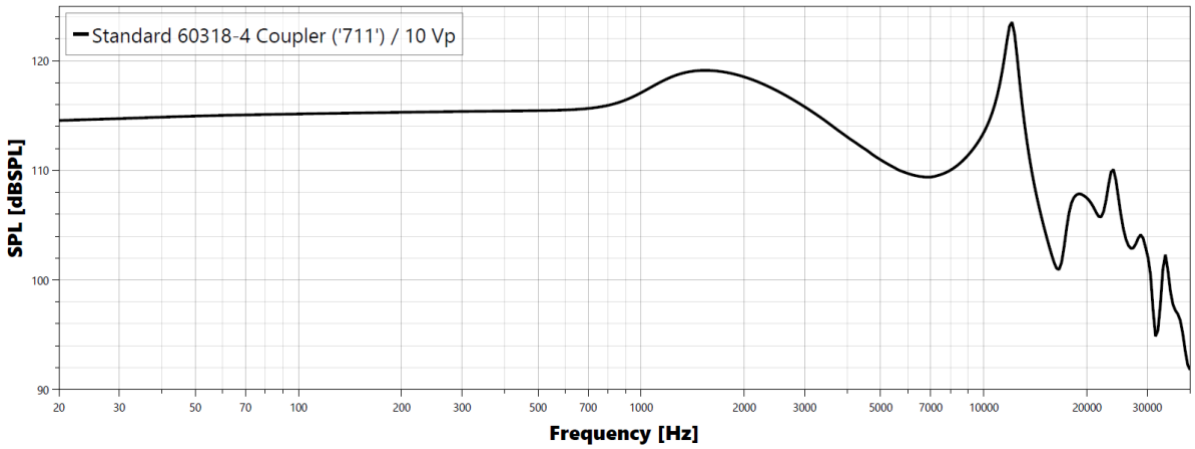


Figure 4. **Reference SPL curve at max volume, 10V_P (Conamara 6mm, in IEC 60318-4 coupler)**

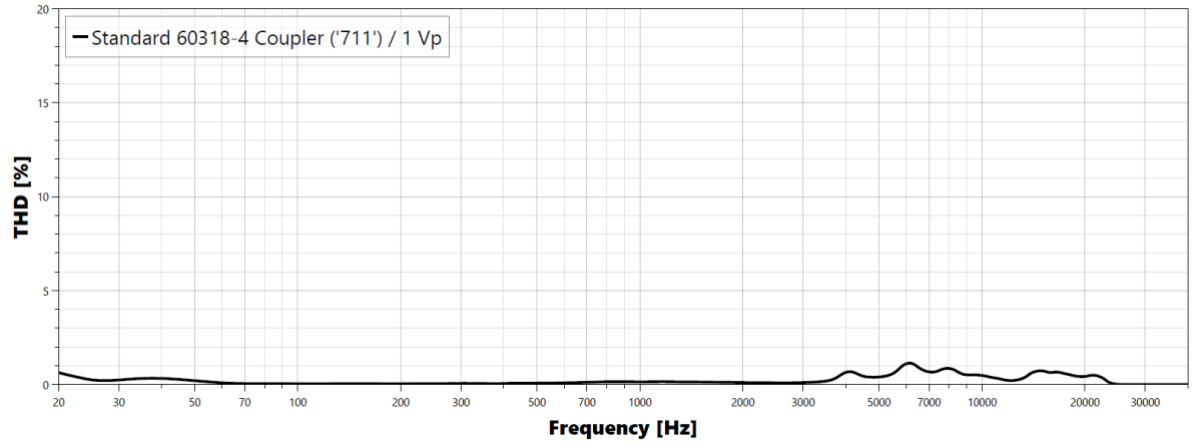


Figure 5. **Reference THD curve at 1 V_P, resulting in 94 dB@1 kHz (Conamara 6mm, in coupler IEC 60318-4)**

USound also developed an algorithm to improve the speaker linearity. It is called Active Linearization Algorithm ('ALA'). It applies signal processing to the audio signal in order to compensate for non-linearities in the speaker. After fine tuning within the application, it lowers the THD significantly while keeping the SPL unchanged (difference below 0.5 dB). As a reference of achievable performance, when using the speaker alone in the standard Coupler IEC 60318-4, take a look at **Error! Reference source not found.**. For low frequencies the THD stays below 1% with a maximum value is 3% at 6 kHz.
ALA can be implemented in an external processor, not part of the Kore 4.0 UMC-P04C06012F integrated audio module.

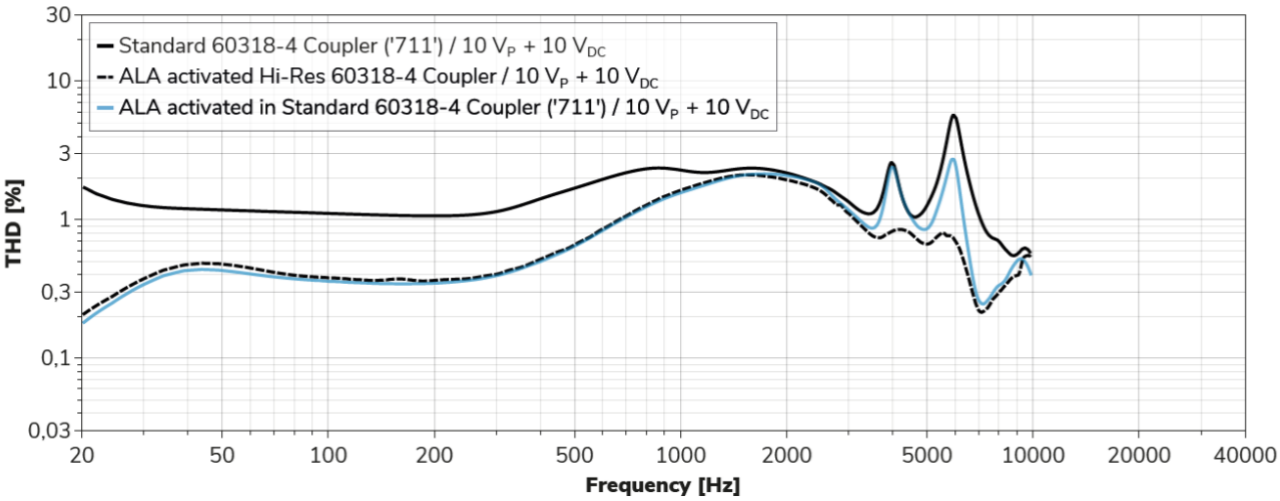


Figure 6. THD of Conamara only at 10 V_p + 10 V_{DC} drive (in logarithmic scale), measured with and without the ALA (see above) with the standard 711-Coupler (IEC 60318-4) and with the Hi-Res Coupler at 10 V_p + 10 V_{DC} from GRAS. The latter replicates the frequency response above 10 kHz more accurately

ACOUSTIC MEASUREMENT SETUP

The integrated audio module UMC-P04C06012F can be measured with a coupler (i.e. IEC 60318-4) for acoustic evaluation. For proper and easy placement, the use of the Carme Kit 6mm (UJ-E1040C06) is recommended (see also Figure 7). It includes the coupler adapter with a gasket that ensures good sealing between the module and the coupler. For fixation the mechanical holder combined with a gasket (included along with the UMC-P04C06012F) is needed for pressing the module onto the coupler adapter.
The flex PCB part of the integrated audio module UMC-P04C06012F is fed through one of the four slits of the coupler adapter to the outside. For the electrical connection simple connection to the header is recommended.

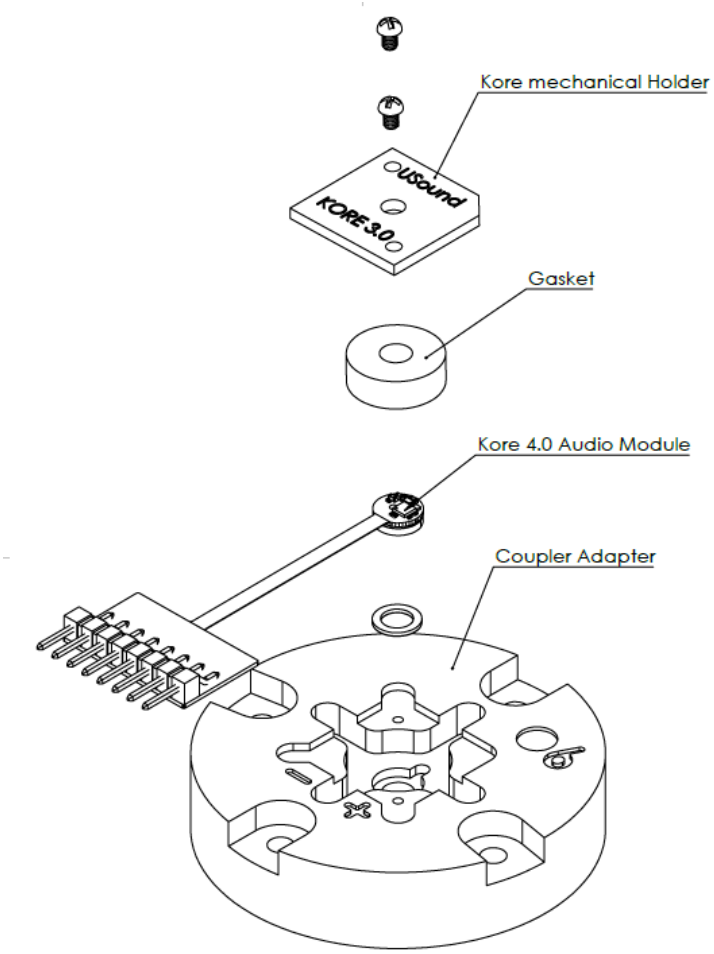


Figure 7. Coupler adapter assembly for acoustic measurements

AUDIO MODULE INTEGRATION

The integrated audio module Kore UMC-P04C06012F offers a robust design for evaluation purposes (with a long and robust connection interface). For the final product, a customized connection FPC is recommended.

The audio module already provides the necessary sealing between MEMS speaker and amplifier PCB. Nevertheless, the front and the back side of the audio module need to be acoustically separated in the application. This can be achieved using a gasket between the front shell of the housing (or holder) and the MEMS speaker to ensure proper sealing, alternatively glue can be used. This will further ensure waterproofness (IPx8) of the final product from the front.

An example of the audio module integration into the TWS solution can be seen in Figure 8.

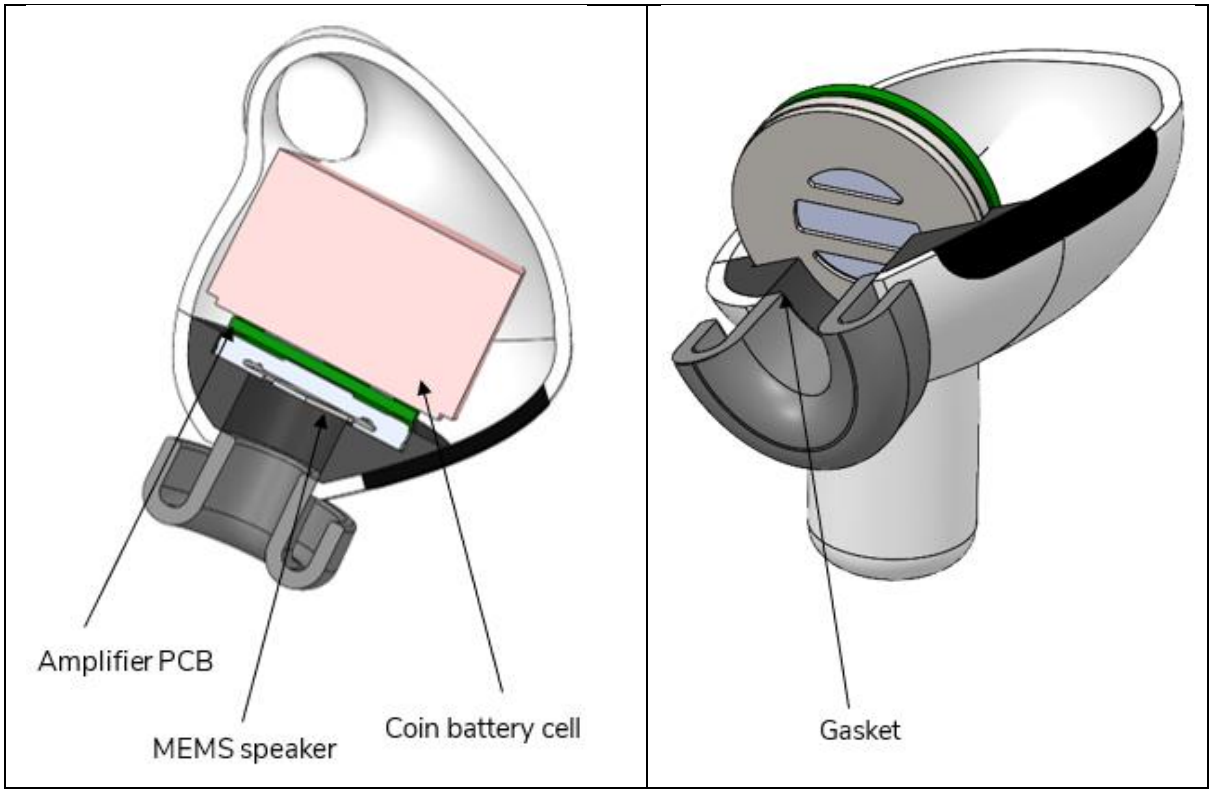


Figure 8: **Integration example into TWS solution.**

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