# DANUBE

UAM-P 10L10 (LEFT SIDE)
UAM-P 10R10 (RIGHT SIDE)

DATASHEET

The Danube audio module provides the best-in-class ratio between audio performance and needed mechanical volume. It can be used to equip glasses with an appealing sound experience by combining ED woofer and MEMS tweeter in a 2-way audio system.

The built–in amplifiers and DAC allow customers to use I2S as digital audio input for the module.

There are two versions of the audio module – one for the left side (Danube Left) and a mirrored version for the right side (Danube Right).
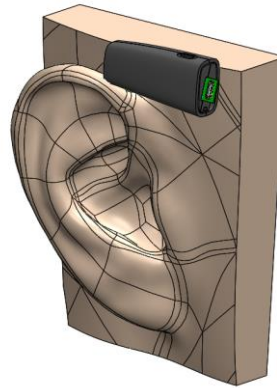
FEATURES

- 2-way audio system with one electro dynamic woofer (ED) and one MEMS tweeter to achieve full bandwidth performance

- Dipole configuration for woofer to get maximum sound directivity towards the ear canal

- Power amplifiers and DAC integrated in audio module for optimal signal integrity and form factor

- Audio input interface is I2S

- Configurable via a I2C interface

APPLICATIONS

- VR and AR glasses
- Wearables

TABLE OF CONTENTS

1 INTRODUCTION

The Danube Audio Module is an active, 2-ways speaker box with digital input that integrates into the host system. This document describes the prototype, version 1.0, suitable for testing the following functions:

- Audio characteristics, stated in section 3.1
- Electronic characteristics stated in section 3.2

The Danube audio module consists of the following main functional elements:

- Audio module housing parts include part A, holding the speakers including gaskets and glue (Figure 1), and part B, holding the PCB (Figure 2).
- Speakers:
  - 1 x Electro dynamic woofer
  - 1 x MEMS tweeter
- PCB, including:
  - Power amplifiers for woofer and tweeter
  - DAC
  - Supporting passive components

Sealing of the audio module is ensured by using glue between housing parts A and B. All needed acoustic volumes are inside the module and sealed from the environment.
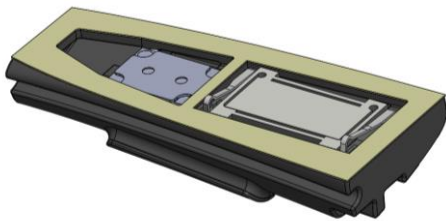

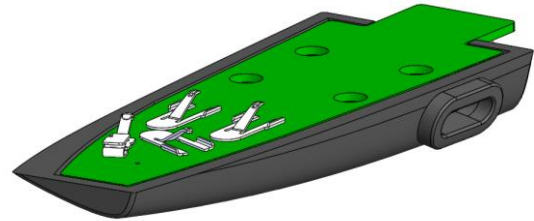
Figure 1: Audio module inside – speaker part.

Figure 2: Audio module inside – PCB part.
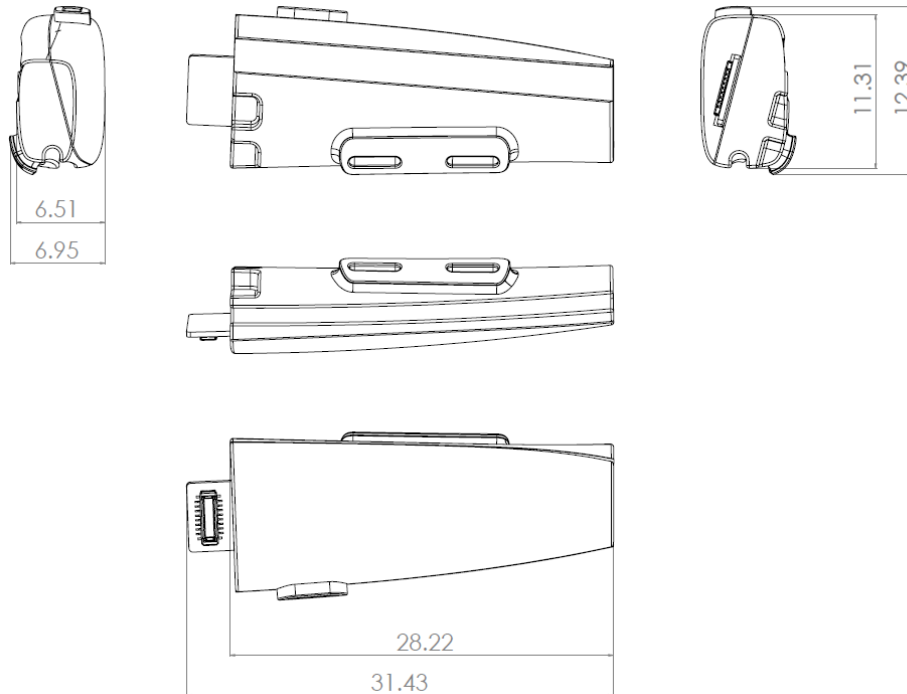
2 SYSTEM OVERVIEW

2.1 MECHANICS

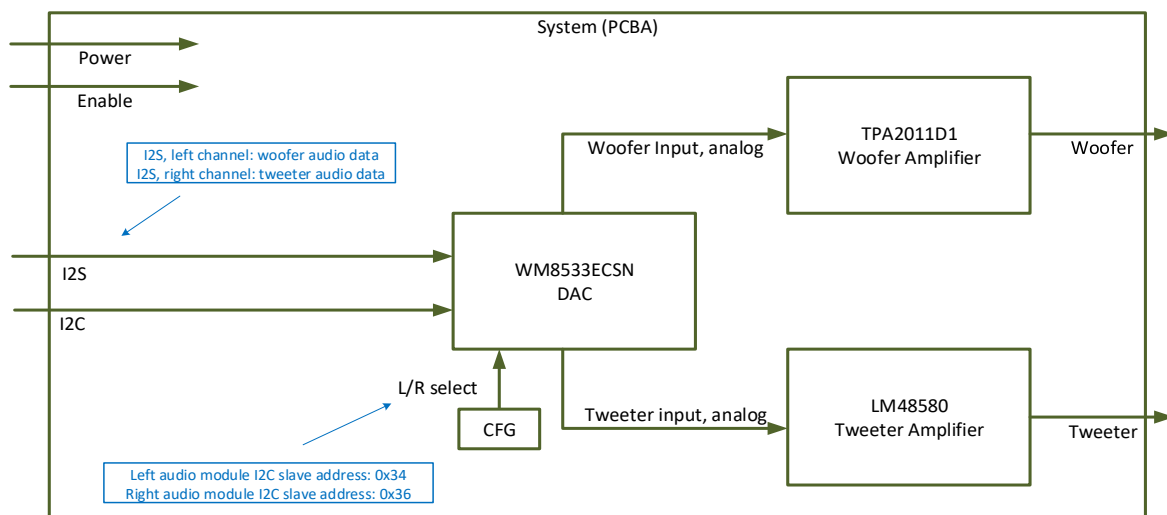Figure 3: Mechanical outline and dimensions.

2.2 ELECTRONICS

Figure 4: Electronic block diagram.

The block diagram in the figure above shows the main electrical functions of the audio module. These are the DAC which converts the digital audio words (I2S) for the woofer and tweeter respectively into analog signals.

The two amplifiers, one is dedicated for the woofer, one is dedicated for the tweeter.

Two different audio modules are provided, one for the left temple (programmable via I2C address 0x34) of the wearables and one for the right temple (programmable via I2C address 0x36).

2.3 CONNECTOR INTERFACE

The audio module interfaces to a SoC host device. In this relation the audio module is a slave and the SoC the master. Find below the signal interface.

Pin name	Type	Description/connection requirement
vdd_3v3	P	Positive supply voltage 3.3V
vdd_1v8	P	Positive supply voltage 1.8V
gnd	P	Ground 0V
enable	I	Active high enable (of the 2 amplifiers)
i2c_scl	I	I2C clock
i2c_sda	IO	I2C data
i2s_bclk	I	I2S bit clock
i2s_mclk	I	I2S master clock
i2s_lrclk	I	I2S word select (left/right)
i2s_sd	I	I2S data in

Table 1: Electrical signal interface between audio module and host SoC.

For connecting to the main board, a 16-pin connector is defined according to the outline in Figure 5 below. For increased robustness, a few of the power and ground signals are multiplied on the connector. This is also visualized in Figure 5.

A more detailed visualisation of the connector and where to locate pin 1 is showed in Figure 6 and Figure 7.

In addition, USound is able to provide a Danube test system, a connector board, necessary cables and user documentation. With this test system package, the Danube module can easily be tested electrically or acoustically when stimulated from a PC.

vdd_1v8	1	ST1	2	i2c_scl
i2c_sda	3		4	enable
i2s_lrclk	5		6	gnd
i2s_bclk	7		8	i2s_sd
gnd	9		10	i2s_mclk
gnd	11		12	gnd
vdd_3v3	13		14	vdd_3v3
vdd_3v3	15		16	vdd_3v3

MO_505070-1622

Figure 5: 16-pin connector outline.

Left PCB
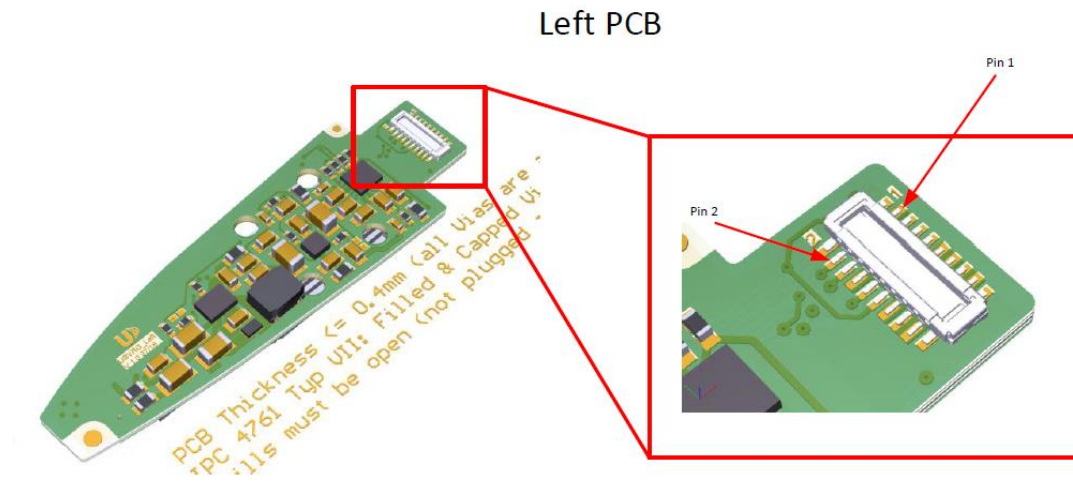
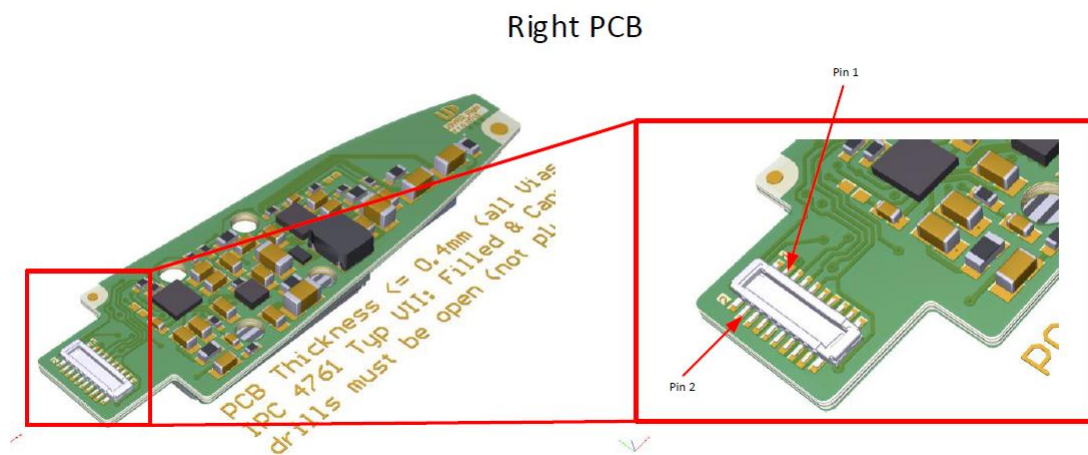Figure 6: Left audio module pin definition.

Right PCB

Figure 7: Right audio module pin definition.

2.4 CONFIGURATION

The I2S audio protocol configuration is done by programming the corresponding config registers in the Cirrus Logic DAC (inside Danube) via I2C. For the details on this refer to the WM8533 user manual, which can be found here:
https://www.cirrus.com/products/wm8533/

The SW delivered with the Danube test system ensures that the DAC and remaining audio module is configured correctly for testing.

2.5 DATA STREAM

The left and right audio modules receive their audio data from the system host SoC which must be equipped with (minimum) two I2S interfaces – let's call these I2S D0 and I2S D1.

These two I2S data lines will be connected; I2S D0 to the left audio module, and I2S D1 to the right audio module. Data on the two I2S buses must be synchronized in order not to create a phase delay between left and right. The i2s_mclk, i2s_bclk, and i2s_ws/i2s_lrclk signals should be common to both audio modules.

Inside the host SoC DSP, I2S audio data for the speaker modules will be split from a stereo (two) channels audio stream to four channels:

- Channel 1 (I2S D0): Left Woofer (DAC Left analog output)

- Channel 2 (I2S D0): Left Tweeter (DAC Right analog output)

- Channel 3 (I2S D1): Right Woofer (DAC Left analog output)

- Channel 4 (I2S D1): Right Tweeter (DAC Right analog output)
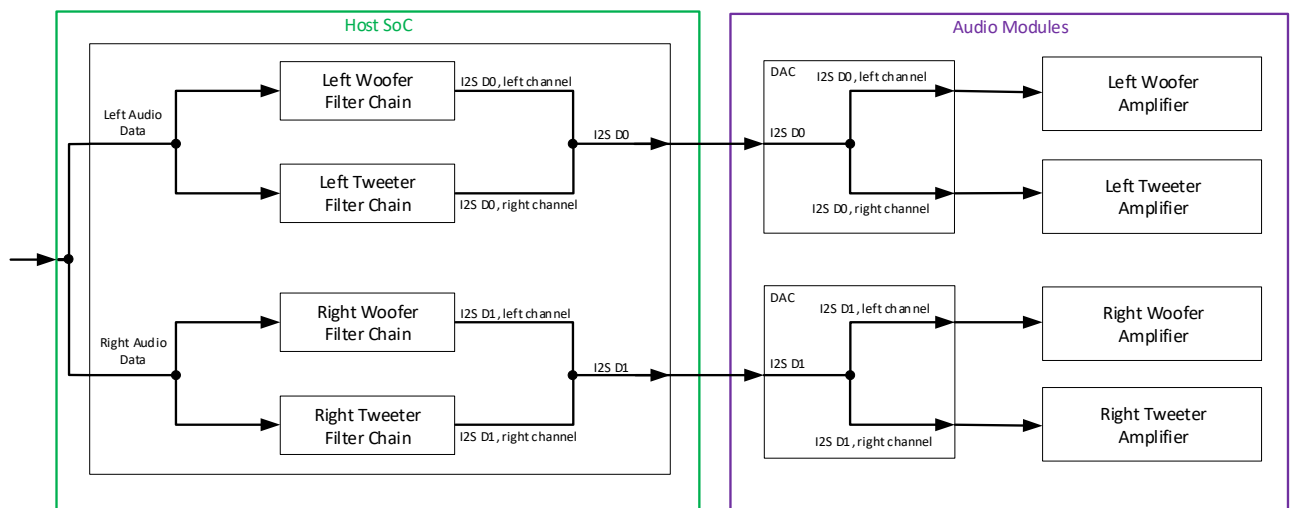
Figure 8 illustrates this.

Figure 8: I2S routing in the host SoC DSP and connection to left/right audio modules.

3 SYSTEM PERFORMANCE SPECIFICATIONS

3.1 AUDIO CHARACTERISTICS

Performance specifications:

Requirement	Description	Min.	Typ.	Max.	Unit
SPL	SPL in the range of 500 Hz to 20 kHz	65	70	---	dB
Crossover (*)	Crossover frequency for 2-way audio system	3.5	4	4.5	kHz

(*) The crossover is actually not performed inside the audio module, but rather in the DSP of the Host SoC. The specification here is the recommended crossover frequency.

Functional specifications:

Requirement	Description
Woofer	Electrodynamic type: 6 x 12 x 2 mm
Tweeter	MEMS type: 6.7 x 4.7 x 1.6 mm – USound Adap
Dipole	Woofer is implemented in a dipole configuration for directivity purpose
Meshes	No Acoustic meshes are included

The performance above is achieved with Danube audio module placed on an artificial head (type Neumann KU100, with a modified face/nose to fit glasses) like shown in the picture below.
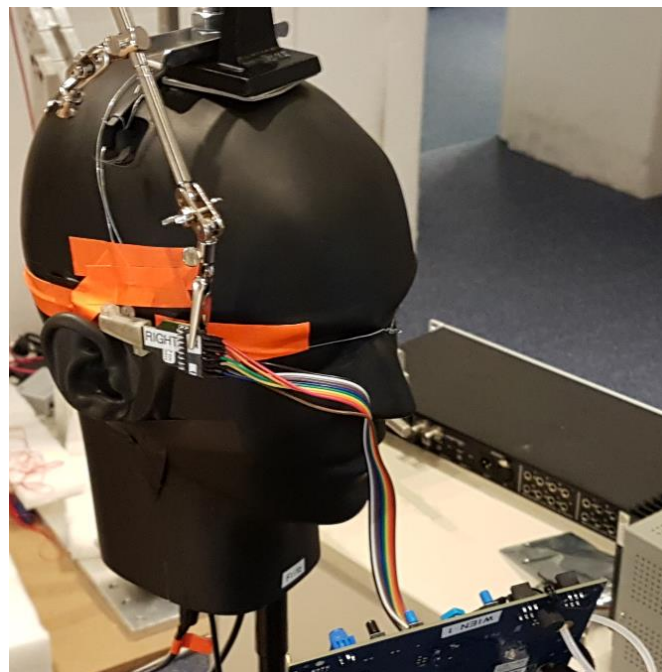

Figure 9: Measuring the Danube audio module.
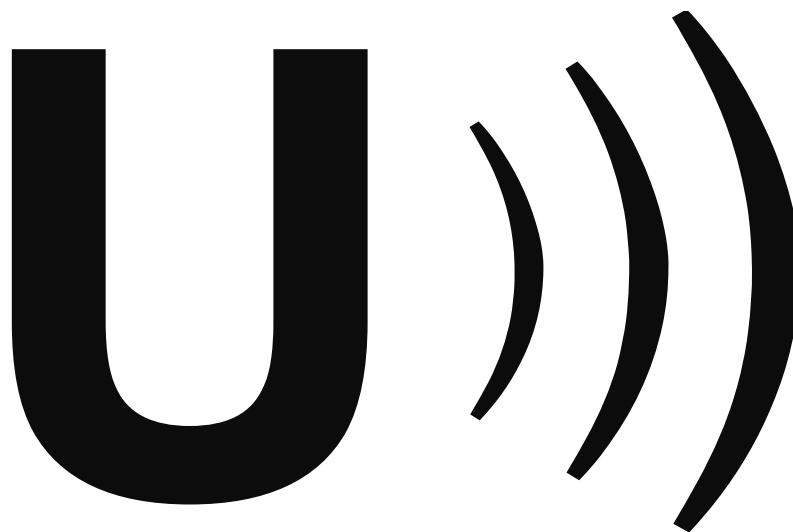
3.2 ELECTRONIC CHARACTERISTICS

Requirement	Description	Min.	Typ.	Max.	Unit
Main power supply					
$I_{PEAK-3V3}$	Peak current consumption for the 3.3 V power rail			260	mA
$I_{PEAK-1V8}$	Peak current consumption for the 1.8 V power rail			20	mA
vdd_3v3	Input supply range for 3.3V supply domain	2.97	3.3	3.63	V
vdd_1v8	Input supply range for 1.8V supply domain	1.62	1.8	1.98	V
Digital interface					
V_{IH}	Input High Level	0.7 x vdd_1v8			V
V_{IL}	Input Low Level			0.3 x vdd_1v8	V
V_{OH}	Output High Level	0.9 x vdd_1v8			V
V_{OL}	Output Low Level			0.1 x vdd_1v8	V
Enable pin					
$V_{IH,EN}$	Logic High Input Threshold for enable signal	1.3			V
$V_{IL,EN}$	Logic Low Input Threshold for enable signal			0.35	V

3.3 OPERATING CONDITIONS

Requirement	Description	Min.	Typ.	Max.	Unit
Temperature	Temperature range for wearables	10	25	45	°C

4 ABBREVIATIONS

Term	Definition
AR	Augmented Reality
DAC	Digital-to-Analog Converter
ED	Electro-dynamic
I2C	Inter-Integrated Circuit – serial communication protocol
I2S	Inter-Integrated Circuit Sound – serial communication protocol for audio
MEMS	Micro-Electro-Mechanical Systems
PCB	Printed Circuit Board
SoC	System on a Chip
SPL	Sound Pressure Level
VR	Virtual Reality

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