HEADSET DEVICE UTILIZING BONE CONDUCTION TECHNOLOGY WITH ACTIVE VOICE PASSTHROUGH

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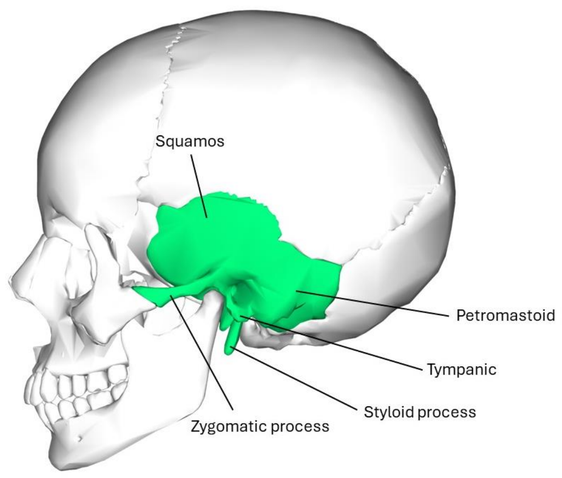
1. Introduction

Bone conduction technology represents an innovative approach to sound transmission by directly stimulating the inner ear with vibrations transmitted via the skull bones, bypassing the outer and middle ear. This technology has found diverse applications, including medical devices for diagnostics and treatment of conductive hearing loss, recreational headphones that allow the user greater environmental awareness compared to traditional headphones, and specialized communication tools for the military and police. Advances in technology of batteries, microelectronic components, and energy transducers have contributed to the improvement in the quality and availability of these devices, making them a valuable alternative to traditional sound transmission methods.

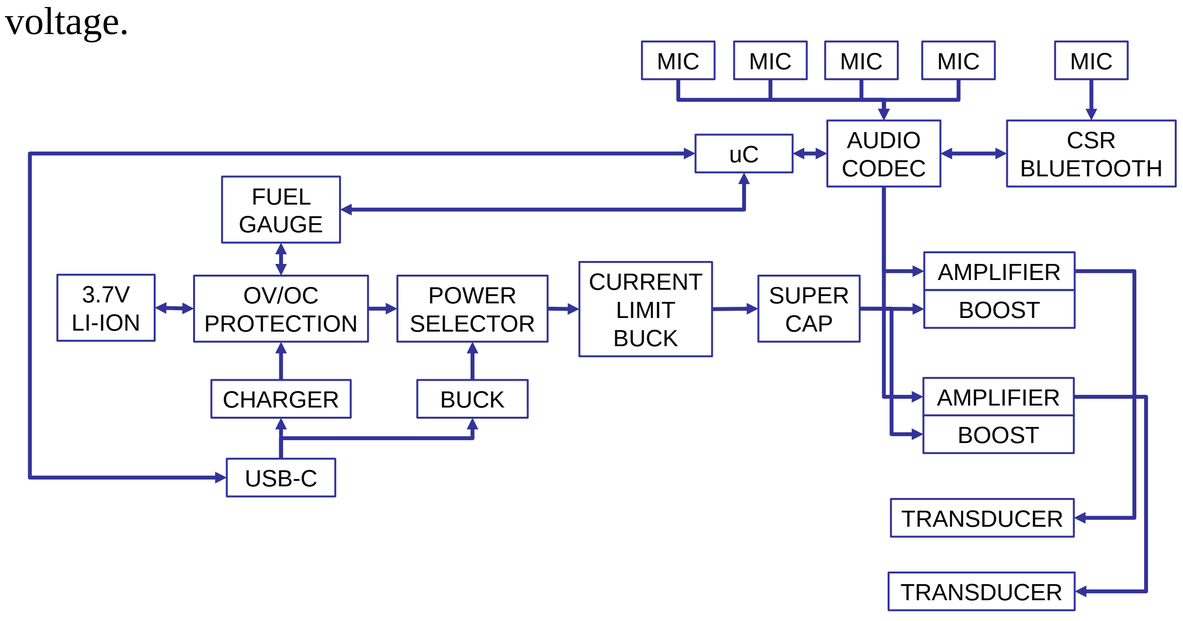
2. Problem description

The aim of this project was to design a complete sound reproduction device using bone conduction technology. The device must be powered by a lithium-ion battery and designed for minimal energy consumption. Special attention must be given to the microphone and audio subsystem with the goal of enabling the transmission and amplification of the user's voice or the voices of people in the surroundings. The device itself must be designed for mounting on the head, paying special attention to ergonomics and the efficient transmission of vibrations to the mastoid part of the temporal bone.



3. Method

The system architecture is designed to provide maximum flexibility for further development of the device. Selected audio CODEC has a fully analog block that allows the use of 4 digital or 2 analog microphones, adjustment of input preamp gain, mixing with other analog or digital sound sources, and transmission of that signal to output amplifiers in real time. The STM32L4 series microcontroller is responsible for managing the power supply and other circuitry. In addition, it can be configured as a USB sound card, providing the option for digital audio transmission to or from the audio CODEC. The Bluetooth 5.1 module enables wireless connectivity for calls or music listening. Power supply consists of two lithium-ion batteries with a total capacity of 1800 mAh. Several regulators are responsible for raising, lowering, and stabilizing supply voltage.



To protect the batteries from temporary overloads caused by the reproduction of deep tones at high output power, a circuit combining supercapacitors and a buck regulator with current limiting has been built in. If a situation arises where the output amplifiers require more energy than the batteries can deliver, additional energy can be drawn from the supercapacitors.

4. Results

A system with a total of 6 rigid and 6 flexible printed circuit boards has been developed, which are mounted on an elastic chassis similar to a hairband, made of composite materials. It is designed to minimize stretching in the area of rigid PCBs during use, while maximizing stretching in the area of flexible PCBs. Rigid PCBs are secured to the chassis using M1.4 screws, and are arranged (from top to bottom) as follows:

- Left vibrator with output amplifier
- PCB with microcontroller
- PCB with audio subsystem
- PCB with power supplies
- PCB with Bluetooth module
- Right vibrator with output amplifier

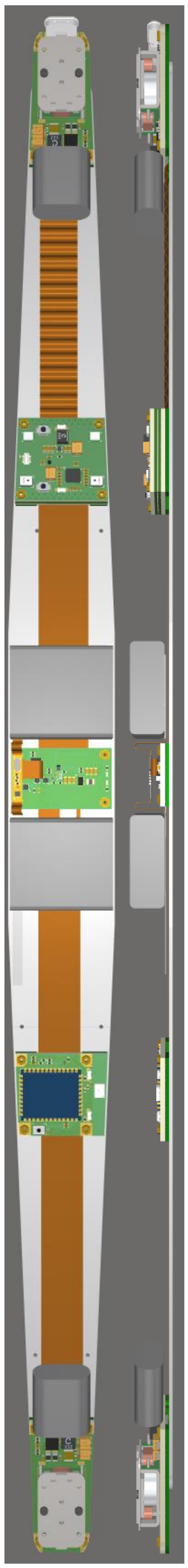
Flexible PCBs are:

- Four connecting FPCs
- BMS PCB
- PCB with microphones

Due to the extreme degree of integration, the microcontroller PCB and the audio subsystem PCB are directly soldered to each other using an additional interconnect PCB.

5. Conclusion

Complete hardware solution has been developed that enables sound reproduction using bone conduction technology. The audio system allows direct routing of sound from the microphone to the output amplifiers with minimal phase distortion, as well as mixing with other audio signals. The modularity of this design allows for quick and inexpensive modifications and upgrades. The developed system can be used as a diagnostic tool and hearing aid for people with conductive hearing loss, as well as for music listening and communication. Compared to existing systems, it has significantly higher output power, better frequency characteristics, the ability of voice passthrough and noise cancelling. Additionally, this system can be software defined, meaning that during production, multiple devices with entirely different functionalities can be made using the same hardware.



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