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Open-Ear Audio: Enhanced, High Quality Solutions for AR/VR Applications

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Abstract

The increasing adoption of AR and VR is driving designers to explore open-ear audio as a new solution for sound playback. This article discusses the use cases and benefits of this new form factor, as well as the challenges involved. It also highlights technologies that can enhance audio performance for these products.

Introduction

Today, it is common to see earbuds and headphones integrated into many aspects of our lives. People wear them while walking, running, working, and taking calls. While they offer a convenient way to enjoy music, podcasts, audiobooks, and phone calls, tuning out the world around you can create problems, such as the inability to hear vehicles approaching or someone trying to get your attention. With that in mind, as well as the increasing demand for augmented reality (AR) and virtual reality (VR) glasses, open-ear audio is growing in popularity.

Figure 1. Smart glasses with speakers embedded in arms.

What Is Open-Ear Audio?

Open-ear audio devices are generally thought of as personal audio playback products that don't block or cover the ears. By allowing outside noise to pass through, these devices enable users to hear their surroundings and maintain situational awareness. Smart sunglasses, prescription glasses, and various AR and VR headsets already incorporate this technology. In a typical application, micro speakers are mounted in the arms of the glasses or the headset strap with the sound directed toward the ears from above.

There are numerous advantages to open-ear listening. For instance, it allows bicyclists to hear traffic while cycling, reducing the risks of accidents. It also prevents physical fatigue as it eliminates discomfort caused by heat or soreness from prolonged earbud or headphone use. When implemented correctly, open-ear audio can provide excellent music quality for the listener while also minimizing sound heard by nearby individuals. Additionally, it eliminates the need to remove headphones or earbuds when interacting with people, facilitating seamless communication. Taking phone calls becomes more natural as there are no barriers blocking the ears and the user's own voice. Traditional earbuds and headphones rely on microphones to pass the user's voice back through the speakers (sometimes called a sidetone) so that the user may hear and adjust their voice to avoid sounding unnatural or too quiet. Try blocking your ears with your fingers and speaking. Understanding yourself becomes challenging and sounds are quite muffled. This is difficult to solve, even with some of the best earbud designs. However, this is not necessary with open-ear devices since they do not obstruct the ears.

The implementation of open-ear audio is increasing significantly in three key use cases: VR headsets, augmented/mixed reality (AR/MR) glasses, and audio/video glasses (Figure 2). In the VR space, many manufacturers have already adopted open-ear solutions to reduce the size, weight, and complexity of head-mounted displays (HMDs). This integration eliminates the need for external headphones. Apple's recent release of the Vision Pro, featuring a sophisticated open-ear audio

system, spatial audio integration, and 3D ear-mapping, showcases the advancements in this field. With VR headsets now capable of viewing the outside world using cameras, the ability to hear one's surroundings becomes crucial, and we can expect to see open-ear audio as a frequently adopted solution (Figure 3).

In the case of AR glasses, open-ear audio is a vital component of the overall experience. Immersive mixed-reality visuals are incomplete without sound effects. Further improvements in spatial audio with headtracking capabilities will enhance the believability of these experiences. Additionally, there are specific audio requirements for enterprise and industrial use cases, which often operate in loud and acoustically challenging environments, such as factory floors or car repair shops. Maintaining situational awareness while conveying information clearly is critical in such settings.

One of the most widely applicable use cases in the near future will be glasses with embedded mics and speakers. This form factor allows for quick access to voice assistants, seamless phone calls, and music playback. If glasses capable of recording video gain in popularity, open-ear audio playback will be included as well. It is not difficult to imagine a future where audio glasses become ubiquitous, with widespread adoption possible within the next decade.

Figure 2. Future smart glasses will integrate many visual and audio features.

While open-ear audio technology offers numerous advantages, it also presents significant challenges. Head-worn devices need to be lightweight and provide long battery life for extended use. Efficiency becomes crucial in the audio signal path, especially when power-intensive features such as video recording or visual displays are incorporated. Additionally, these devices need to be fashionable and attractive if worn in public, and charging them should not pose an inconvenience, particularly for prescription glasses. Furthermore, consumers now expect high quality sound, as earbuds have set a high standard in audio performance.

The acoustic challenges of open-ear audio implementations are straightforward but not easily overcome. Since the speakers are not enclosed like headphones or earbuds and may be located farther away from the ears, they can lose bass energy in free space. Moreover, they require more power than typical headphone amplifiers, calling for the use of a different line of audio amps. Industrial design considerations are also important, as placing the speakers farther away increases the risk of sound being heard by nearby individuals.

Figure 3. Better audio can make a difference in immersive VR experiences.

Analog Devices offers a portfolio of audio amplifiers with the right specifications and features to meet many of these constraints. ADI also provides system solutions for open-ear audio, including voice algorithms,[1] battery management, and charging products[2] that tackle these unique challenges. To maximize audio performance, speaker amplifiers with exceptional efficiency and high power in compact packages are essential. Implementing current and voltage (IV) feedback, which tracks the voltage and current passing through the speaker, is another way to optimize the performance of smaller speakers. ADI's patented speaker protection algorithms leverage this speaker IV data to further enhance the performance of micro speakers used in these systems.

Two Approaches: Digital Plug and Play Amplifiers and Smart Amplifiers

The MAX98361, a plug and play Class-D amplifier from ADI, enables product designers to quickly create high quality audio solutions without the need for I^2C programming. It combines the simplicity of an analog amplifier with the performance and efficiency of a digital input amplifier. This amplifier is an excellent choice for smart glasses projects where audio design may not be the primary focus, as it requires minimal expertise. Additionally, it natively supports multichannel TDM audio, meaning that multiple speakers[3] can be placed on each side for greater control and immersion.

Additional solutions consist of smart Class-D and Class-D/G amplifiers. These amps utilize in-chip IV feedback ADCs to accurately determine the thermal and excursion limits of micro speakers. This knowledge allows speakers to be driven beyond their rated specifications without the risk of damage. ADI also offers a suite of algorithms, collectively known as Dynamic Speaker Management™ (DSM) solutions, to optimize speaker performance based on IV data. DSM has already been integrated into various popular SoCs.

One of these amplifiers, the MAX98390, features a built-in digital signal processor that directly integrates these algorithms into the amplifier itself. This integration reduces the MIPS load on the host processor. This amplifier is programmed using the complementary, intuitive software, DSM Sound Studio, enabling quick tuning with demonstrable benefits.

Depending on the application, the MAX98390 can deliver deeper bass by up to two octaves and increase loudness by up to 2.5× (Figure 4). Additionally, it features industry-leading power consumption specifications[4] for a boosted Class-D/G amplifier. The perceptual power reduction (PPR) feature further enhances efficiency by up to 25% without compromising audio fidelity. The MAX98390 offers system design flexibility, as it includes a programmable boost converter with envelope tracking for optimal efficiency.

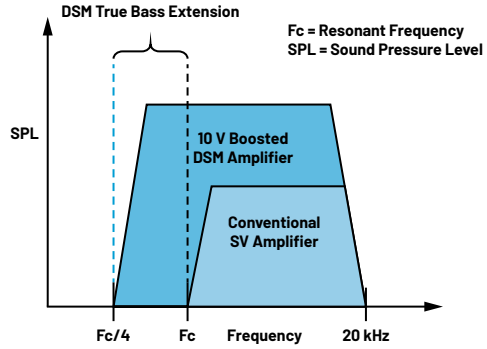

Figure 4. Illustration of improvements to frequency response and loudness using DSM.

ADI has also recently introduced the MAX98388, a new Class-D amplifier specifically designed for AR/VR and smart glasses applications. This amplifier incorporates IV feedback for smart amp features and boasts an efficiency of up to 90%.

Conclusion

Whether you are developing glasses with integrated speakers to provide an exceptional audio experience for your customers or designing industrial mixed reality glasses that require loud playback in challenging environments, more and more optimized solutions are coming to market. Smart audio amplifiers with IV feedback and speaker management algorithms are a great way to maximize performance in these challenging form factors. Other emerging technologies, such as parallel battery management ICs[5] and low latency audio digital signal processors[6] for voice processing will help with widespread adoption of VR/AR and other open-ear audio form factors as well. These solutions help improve runtime and minimize downtime, ensuring that your customers can quickly get back to enjoying their music. The future of audio is on the horizon, and you're going to like what you hear.

References

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About the Author

Ryan Boyle holds an electrical engineering degree from UMass Lowell with a minor in sound recording technology. Prior to joining Analog Devices, he worked at Bose Automotive Systems in roles for product marketing and concept development. He has a lifelong passion for audio and music.