

**Qualcomm**  
developer network

# An Introduction to Audio for Developers

Definitions, foundations, use cases, and a peek into  
the future to help inspire you

# Smart, truly wireless audio is here.

Here's what developers need to understand first:



With the enormous rise in audio content paired with the rapid adoption of audio technologies, the wireless audio device opportunity is projected to grow from USD \$57.3 billion in 2020 to USD \$134.2 billion by 2025,<sup>1</sup> clearly signaling that a truly wireless age is here. As these new audio technologies become more accessible, and sound quality continues to increase, there is a shift in how wireless devices are being used, and what they are being used for.<sup>2</sup> These breakthrough technologies are changing the way people connect, communicate, and engage with personal audio devices, and that provides many new opportunities for developers to build innovative solutions for both consumers and the industry.

This eBook is intended to help developers better understand the hardware and software available for audio technology by providing the terminology used, explaining some of the foundational technologies, looking at some use cases, and peering into the future. All of this is intended to help prepare and inspire developers entering the world of developing audio solutions. In addition, we've included links to tools and resources for further learning opportunities and to organizations dedicated to helping developers entering this exciting area.

<sup>1</sup> <https://www.marketsandmarkets.com/Market-Reports/wireless-audio-device-market-1275.html>

<sup>2</sup> <https://www.qualcomm.com/news/onq/2019/09/05/state-play-2019-whats-next-audio-tech>

# First, let's get the jargon straight

As with any technology sector, learning the vocabulary first can help you understand the fundamentals of how things work, make informed choices on tools, and sometimes even help you decide what or how you'll create something. Here are a few of the more common terms (with links to deeper dives) that you'll find used in the audio development industry:

**TERM** [\(click to learn more\)](#)

**DEFINITION**

**Ambient Noise Level**

Sometimes called *background noise level*, *reference sound level*, or *room noise level*, it is any environmental or background sound that exists before a new sound source is added.

**Analog Signal Processing**

A type of signal processing conducted on continuous analog signals by some analog means. *Analog* indicates something represented mathematically as a set of continuous values. This differs from *digital*, which uses a series of discrete quantities to represent signals.

**Audio Codec**

A device or computer program capable of encoding or decoding a stream of audio data.

**Audio Compression**

A reduction in the amount of audio data, achieved by algorithms to reduce the transmission bandwidth and storage requirements. These algorithms are defined as either *lossy* (which throws away non-critical data to save space), or *lossless* (which tries to reduce file size while maintaining the same audio quality).

**Digital Signal Processors (DSP)**

A DSP takes real-world signals like voice, audio, video, temperature, pressure, or position that have been digitized and then mathematically manipulates them. A DSP is designed to perform mathematical functions like *add*, *subtract*, *multiply*, and *divide* very quickly.

**Direction of Arrival (DOA)**

An algorithm used to denote the direction from which a propagating wave arrives at a point where a sensor array is located.

**Dynamic Range Compression**

The process of lessening the dynamic range between the loudest and quietest parts of an audio signal. This is done by boosting the quieter signals (upward compression) and attenuating the louder signals (downward compression).

**Psychoacoustics**

The science of how the brain understands sounds. By manipulating known quirks in the way humans perceive sound, compression algorithms can cleverly remove details that most human ears won't miss.

**Pulse Code Modulation (PCM)**

A method used to digitally represent sampled analog signals. It is the standard form of digital audio in computers, compact discs, digital telephony, and other digital audio applications. In a PCM stream, the amplitude of the analog signal is sampled regularly at uniform intervals, and each sample is quantized to the nearest value within a range of digital steps.

**Signal to Noise Ratio (SNR)**

A measure used in science and engineering that compares the level of a desired signal to the level of background noise. SNR is defined as the ratio of signal power to the noise power, often expressed in decibels.

# A look at the foundational technology that makes audio work

Before developing audio applications or creating embedded audio technology solutions, developers should really understand the basics of what's happening under the hood. Likewise, when choosing a codec to best meet the needs for what you are developing, a basic understanding of how wireless technologies work with each codec to supply and enhance raw audio signals is also beneficial. Below is an overview of some of these foundational audio and wireless technologies.



## Foundational audio technologies

**Acoustic Echo Cancellation** – AEC involves first recognizing the originally transmitted signal that re-appears (with some delay) in the transmitted or received signal. Once the echo is recognized, an AEC processor removes the potential echo signal by subtracting it from the transmitted or received signal. Echo is measured as *echo return loss* (ERL) and the performance of an echo canceller is measured in *echo return loss enhancement* (ERLE).

**Active Noise Control** – ANC, also known as *noise cancellation*, or *active noise reduction* (ANR), is a method for reducing unwanted stationary sound by using microphones and speakers to reduce background and surrounding noises. For non-stationary sound *adaptive active noise cancellation* (AANC), also known as *adaptive interference cancellation* (AIC) adds machine learning (ML) algorithms that digitally adapt the level of noise cancelling to the surroundings.

**Automatic Speech Recognition** – Powering today's *voice-user interface* (VUI) that makes spoken human interaction with *voice command devices* (VCD) possible, is *automatic speech recognition* (ASR). ASR software uses *natural language processing* (NLP) to analyze, understand, and derive meaning from human language in a smart and useful way. The software breaks the speech down into bits it can interpret, converts them into a digital machine-readable format, and then analyzes the pieces of content. From there, the software makes determinations using language decoding based on deep learning neural networks and speech patterns, and makes hypotheses about what the user is actually saying. After determining what the users most likely said, the software takes appropriate action.



**Beamforming** – also known as [spatial filtering](#), is a technique that focuses a wireless signal towards a specific receiving device using DOA, rather than having the signal spread in all directions from a broadcast antenna. The resulting, more direct connection is faster and more reliable than it would be without beamforming

**Equalization** – also called [EQ](#), is essentially an audio signal processor used to control the attenuation (the turning up or down) of different audio frequencies to optimize or change the character of the resulting sound of the audio signal. By using a real-time analyzer and a reference signal, EQs are used to help ensure the resulting sound closely matches the source or original sound.

### Primary audio wireless technologies

**Bluetooth Audio** – allows wireless connectivity between devices and streaming services through the pairing of a source device (e.g., phone or tablet) and a sink device (wireless speaker or headphones). Offered in multiple codecs, the primary characteristics that distinguish Bluetooth Audio is the time it takes for a DSP to decode the encoded audio to reduce latency, the audio compression algorithms used to improve audio quality, and the overall energy efficiency to save battery life. Some codecs, such as [Qualcomm® aptX™ Adaptive Audio](#), are less math and memory-intensive and are designed to reduce latency and bandwidth. The upcoming Bluetooth Low Energy standard combines the convenience of previous versions, but now significantly lowers power consumption. LE Audio is aimed at peripheral devices, like Smartwatches, which operate on batteries and don't require high data rates or constant data transmissions.

**Dolby Digital and Digital Theater Systems (DTX)** – are both compression-based surround sound digital audio coding techniques designed to reduce the amount of data needed to produce multi-track, high-quality sound. Both are offered as codecs for 5.1, 6.1, and 7.1 setups (i.e., the first number represents the number of surround speaker channels, and the 1 represents the subwoofer channel). The primary difference between the setups is how they actually encode the audio (compression versus bit rate). The lesser the compression used in the encoding, the better the signal represents the original source and realism. Additional differences include how each handles SNR and speaker calibration. Psychoacoustics data reduction techniques are also used in PCM signal output to save space while preserving high-fidelity sound, which is virtually identical to the lossless studio original recording.

## Use cases

Many of these newer audio technologies are opening up interesting areas of development. The example use cases below highlight how ANC with super-low latency leak-through (hearables), VUI and VUD with NLP (automotive), and multi-speaker wireless networking surround sound (home theatre), can now help you develop solutions that are more context aware, safer, and highly personalized.



### Hearables

Respond to the world around you with a truly natural awareness of surroundings.



### Automotive

Recognize audio events and acoustic scenes to make intelligent safety adjustments.



### Home theatre

Pinpoint the exact location to place a sound in space and over time for true immersion.

## What's new in audio technology development?



One of the fastest growing areas of the audio technology ecosystem are **truly wireless earbuds**. In our State of Play Report 2020, earbud users stated they are specifically looking for high-quality sound, complete freedom from wires, extended battery life, and a seamless experience for a wider range of applications, including music listening, voice calls, and mobile gaming. Equally important to them is the robustness of the Bluetooth connection as audio glitching or dropouts are identified as deal breaking.

Here are some additional innovative Qualcomm TrueWireless™ audio technology developments that are happening with our flagship Bluetooth Audio SoC to inspire you with possibilities for wireless earbud development:

**Qualcomm TrueWireless Mirroring** is designed to seamlessly swap between the earbud that's connected to the smart device and the earbud that mirrors the connection, all without user intervention.

**Integrated support for many voice assistants** for both push-button voice activation and trigger/wake-word activation for multiple voice ecosystems. It includes AI that helps devices quickly learn an individual's speech and voice patterns, making the device more secure, reliable, and responsive. Contextual audio detection can selectively pick up sounds in the user's environment and automatically take the right action.

**Robust and low-latency connectivity—aptX Adaptive** is a ground-breaking audio coding technology which combines robust premium audio quality with low-bit rate audio transmission, scalability, and the opportunity for low-latency—designed to create a premium wireless listening experience for end users.

**Bluetooth Low Energy Audio** support for the upcoming [Bluetooth Low Energy standard](#) will enable audio sharing in both personal and location-based applications.

**Integrated Active Noise Cancelling** uses industry-leading ANC, AANC, with super-low latency leak-through of the outside environment, integrated in the SoC, allowing you to develop applications with a natural awareness of your user's surroundings.

**Improved voice call quality—Qualcomm® cVc™** noise cancellation technology is a suite of algorithms that work on the transmission and receiving path of voice. By using up to three microphones to isolate the speaker's voice, ANC and AEC are used to filter all ambient noise levels and echoes designed to deliver superior audio quality calls.

To learn more, read how to Simplify your true wireless earbud development and sign up for [The Future of Wireless Sound newsletter](#) to get the latest updates from our audio and voice technologies team.

# A peek into the future of audio

So, what comes next? Following are a few examples of the audio trends and gadgets that could be appearing in the near future to inspire you.

**Immersive 360-degree audio**, also called *spatial audio*, is the experience of hearing sounds from everywhere in space. The latest development in surround sound is known as object-based or 3D surround. For earbuds and viewers, 3D offers the best description of this technology because of its ability to make sounds feel as though they are moving through space. You might be able to distinctly hear a helicopter take off from in front of you, hover over your head, and then disappear into the distance behind you.

**Audio Augmented Reality (AAR)** is the use of sound, or audio, as a layer of additional information to augment what the consumer may be hearing and experiencing real-time. It uses GPS and built-in sensors that track location and movement so that location-specific information can be delivered which changes based on movements. An AI voice might be able to quietly tell you a restaurant only has three stars when you look in its direction at lunchtime or tell you exactly what's wrong with your golf swing without letting the people around you know.

**Anti-Noise 3D Noise Cancellation**—speakers that make the inside world a little quieter might be able to use a device that suppresses external noise coming from the outside, to either cancel out noise entirely or cancel out the specific noises that are drowning out the peaceful ones. It's intended to be used mainly on glass windows in your home and to create quiet zones, but could be installed elsewhere.



## Immersive 360-degree Audio

If sound doesn't change as you move, chances are you'll be pulled out of the experience before you even realize it.



## Audio Augmented Reality

Fully immersed in the real world, and at the same time, immersed in a virtual world that is superimposed upon it.



## Anti-Noise 3D Noise Cancellation

It's a striking achievement to make wave and antiwave cancel out perfectly throughout an entire room.

## Connect and learn more here

There are many organizations and companies in the audio space that provide developer resources, training, information, and support that you can access to learn more, and connect with experts or even other developers learning along with you. Of course, [Qualcomm Developer Network \(QDN\)](#) is here for you as well!

### Audio Engineering Society

[aes.org](http://aes.org)

---

### AUDIOAR.ORG

[audioar.org](http://audioar.org)

---

### Dolby Professionals

[professional.dolby.com](http://professional.dolby.com)

---

### Audio Product Education Institute

[audioproducteducationinstitute.org](http://audioproducteducationinstitute.org)

---

### Bluetooth

[bluetooth.com](http://bluetooth.com)

---

### DTS

[dts.com/professional](http://dts.com/professional)

---



## Key developer resources

To learn more about what we have covered, here are further tools, resources, and industry leading reports available (click for more information):

|   |  |
|---|--|
| <b>Qualcomm® 3D Audio Tools</b>   | Designed to help content creators, content hosts, consumer electronics manufacturers and broadcasters create, capture, and render true-to-life immersive 3D audio experiences. |
| <b>3D Audio Plugin for Unity</b>  | Designed to provide superior sound quality, low motion-to-sound latencies, and better performance on devices powered by the Qualcomm® Snapdragon™ platform.                    |
| <b>Adaptive Active Noise Cancellation</b>                                     | Designed to enhance comfort and the user experience for true wireless earbuds by dynamically adapting performance.   |
| <b>cVc Noise Cancellation Technology</b>                                      | A suite of algorithms that work on the transmission and receiving path of voice calls to help deliver optimum voice quality.   |
| <b>aptX Technology</b>  | Next generation dynamically adjustable audio codec designed to deliver robust, low-latency, low-bit rate, high-quality wireless audio.   |
| <b>Qualcomm® Voice Assist</b>   | Next-generation voice interaction capabilities with almost-instant voice wake up, advanced AI-based speech recognition, and dedicated audio hardware.                          |
| <b>Qualcomm® QCS400 Reference Design</b>                                      | Provides optimized reference design to help developers rapidly deploy high-performance voice products.   |
| <b>The State of Play Report 2020: Global Consumer Audio Insights (report)</b> | A survey commissioned to provide a broad global view of how consumers are connecting and communicating, and what they're looking for in their next audio device purchases.     |
| <b>The evolution of true wireless technology (report)</b>                     | Outlines consumer trends, needs, and technologies that will inform and support the next generation of truly wireless technology.   |
| <b>Earbud Reference Design</b>  | Provides optimized reference design to help developers rapidly deploy high-performance audio products.   |
| <b>Low-cost Earbud Reference Design</b>                                       | Provides optimized reference design to help developers rapidly deploy high-performance/low cost audio products.  |

# Innovate with us

Qualcomm Developer Network is a collection of software and hardware tools, inspiring our community of developers to push the boundaries of mobile. We're continuously creating some of the most innovative, powerful and disruptive technologies in the world, and Qualcomm Developer Network is the gateway through which you can discover the tools you need, whether you're building high-performance apps, smart Internet of Things (IoT) devices, immersive virtual reality experiences or other emerging technologies.

[developer.qualcomm.com](https://developer.qualcomm.com)

**Qualcomm**  
developer network