INTRODUCING LOSSLESS AUDIO STREAMING FOR BLUETOOTH AND WHAT IT MEANS FOR CONSUMERS

Abstract

Achieving true hi-res audio requires more than simply finding a service that offers lossless (FLAC or ALAC) streaming. Rather, you need to assure your audio is part of a full end-to-end solution, and for those interested in a wireless solution, not all Bluetooth solutions are created equal.

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Introduction

Apple recently made a splash by announcing that its entire library of over 75 million songs would be available to customers in lossless audio format, with users able to choose from three levels of audio quality: CD (16-bit, 44.1 kHz), HD (24-bit, 48 kHz), or High-Resolution (24-bit, 192 kHz), as shown in Table 1. Apple isn't the first streaming provider to support lossless audio at higher quality. In fact, Apple is late to the game in this regard after being beat to the punch by streaming services including Tidal, Qobuz, Deezer, and Amazon Music, but now high-resolution audio is going mainstream. What makes Apple's decision noteworthy is that lossless audio and high-resolution (hi-res) quality are now open to hundreds of millions of consumers within its vast ecosystem.

Format	Bit Depth	Sample Rate	No of Channels	Data rate	Audio Bandwidth	Max Signal to noise ratio
CD resolution	16bit	44.1KHz	2	1.411 mbps	<22kHz	96dB
HD Audio	24bit	48kHz	2	2.304 mbps	<24kHz	144dB
Hi Resolution	24bit	96kHz	2	4.608 mbps	<48kHz	144dB

Table 1. A summary of audio formats

While audiophiles might have been the vanguard of this dream for lossless and higher quality, interest in better audio experiences has been growing across a variety of fronts. The resurgence of vinyl and the popularity of remastered albums, for instance, are indications of a desire for audio that offers more fidelity to the artist's original intentions.

According to Qualcomm's recent State of Sound survey of 6000 consumers globally, 58% of people listened to more audio during the covid crisis and expect these listening habits to continue. Many of those people are streaming the audio over 5G or WiFi. Think, for instance, about what advanced audio means for streaming movies, TV, gaming, virtual and augmented reality, or even for video conferencing, especially now that remote work and learning have grown so dramatically.

With widespread availability of 5G cellular and Wi-Fi 6 streaming high bandwidth connectivity is seamless and powerful. And as more and more services move toward hi-res and lossless content, those more realistic and immersive audio experiences will become the norm across our daily lives. Increasingly, people also want those experiences without being tethered by a wire– through Bluetooth headphones and wireless earbuds.

While that sounds exciting and transformative, there are a number of important caveats to keep in mind and limitations to overcome in order to assure you are enjoying the full benefits of lossless and hi-res audio when using wireless audio devices. Even the best source file with poor connectivity, can lead to audio drop-outs and glitches either at the receiver or the wireless headphones. The company addressing this across the entire audio chain is Qualcomm. Not even Apple can deliver lossless audio quality end-to-end from phone to earbud.

The Historical Context

A perfect storm has contributed to the current push for lossless and hi-res audio. Perhaps most importantly, available bandwidth and storage advancements have radically transformed what is possible for streaming and downloading music. Most recently, the growth of 5G and high-performance WiFi, with its leap forward in speed and capacity, promises to further accelerate streaming opportunities. Contrast this current state with the situation when music streaming first took hold. Internet and cellular speeds along with storage possibilities were, from this modern context, *severely* limited.

The standard for audio quality has traditionally been CD quality sound (16-bit, 44.1kHz). But streaming a CD losslessly under those earlier bandwidth and storage limitations presented a number of technical challenges. After all, an uncompressed, CD-quality song is roughly 50 MB in size and an entire CD can consume upwards of 700 MB, requiring a transmission data rate of 1.44mbps. Now think back to common internet or cellular speeds when streaming first became popular: it would have taken ages to download or stream a single file that size. Moreover, even if you had the patience to download a music file that size, storage presented another limiting issue. Downloading a full album would have taken a huge amount of space at a time when hard drives, even on top-of-the-line machines, weren't nearly as large as many of today's base models (to say nothing of the huge shift toward cloud-based storage solutions consumers currently available). While individual CD files sizes are no longer the problem of the past, if you have a collection of hundred of albums, it does add up.

In the face of these limitations, a novel solution emerged: file sizes and data rates needed to shrink, and the best way to accomplish that task was to intentionally "lose" some of the audio. MP3 and AAC formats are prime examples of this type of "lossy" audio files. Lossy formats remove some elements to save bit rate and file size without too much disruption. The process, however, is destructive, meaning that the missing content is not reconstituted when the file is decoded. Moreover, because each subsequent encode/decode further removes content from the last version, the compression snowballs to create potentially very bad audio.

In contrast, a "lossless" song, as the name implies, simply means that no data has been removed from the original recording. In lossless audio, all of those extremely low-level sounds that were cut out by lossy MP3 and AAC formats are retained. If you're interested in lossless audio, there are two primary formats to look for: the Free Lossless Audio Coded (FLAC) or Apple Lossless

Audio Codec (ALAC). If you see FLAC or ALAC, you can be assured that you're getting lossless audio, but these aren't supported by Bluetooth.

Limitations remain for finding true Hi-res Audio

While that lossy approach is clearly great for file size, it does come at the expense of audio quality. To understand just how much audio quality is potentially sacrificed, we need to dive into a bit of technical talk. Recall that CD quality set the standard and is expressed as 16-bit, 44.1 kHz. Those last two numbers are key and represent bit depth and sampling rate, respectively.

Let's start with bit depth, which is simply the number of bits of information gathered with each audio sample. Sampling rate, meanwhile, is the number of times per second a sample is taken and represented in kHz. If you think of bit depth like volume and sampling rate like frequency, then increasing each means gaining more information, more frequently.

For a simple analogy, think of it like taking a weather measurement: increasing bit depth would be like measuring the outside temperature at 95.35879 instead of 95.4; increasing sampling rate would be like checking the temperature more often each second. From a mathematical standpoint, the greater the number of bits taken per sample and/or the greater number of times per second a sample is taken, the better the quality.

This gets us to bitrate, which is simply bit depth multiplied by sampling rate multiplied by the number of channels under consideration. Mono audio has one channel, while stereo has two channels (left and right). So, CD quality sound has a bitrate of 1,411 Kbps: 16-bit depth x 44.1kHz sample rate x 2 channels (see Table 1).

The greater the bitrate, the more realistic and richer your audio sample will be. A higher bitrate means more detail and more dynamic range in the audio, which can translate into deeper bass, higher treble and greater nuance and distinction in the recording. For audiophiles, this means a richer, more immersive music experience. This is where HD and hi-res audio are important. Each goes beyond CD quality by offering an even greater bitrate. HD audio, for example, delivers 24-bit 48kHZ quality (a 2,304 kbps bitrate). Hi-res audio, meanwhile, starts at 24-bit 96kHz (4,608 kbps) and, depending on the service, can deliver up to 24-bit 192kHz audio (9,216 kbps) as shown in Table 2.

Format	Bit Depth	Sample Rate	No of Channels	Data rate	Max Signal to noise ratio
Hi-Res Audio	24bit	48kHz	2	2.304 mbps	144dB
Tidal MQA	24bit	96kHz	2	4.608 mbps	144dB
Apple Music Hi-Res	24bit	196kHz	2	9.216 mbps	144dB
Amazon Music Ultra HD	24bit	196kHz	2	9.216 mbps	144dB

Table 2. A summary of streaming Hi-Res audio services

This brings us back to standard/SD streaming and traditional MP3 and AAC files (i.e., not CD, HD, or hi-res). Thanks to lossy compression, each of these options typically caps out at a mere

320 kbps bitrate. That huge reduction in bitrate made files easier to download and stream but at the expense of overall audio quality.

This type of tradeoff made perfect sense at the time when streaming first became the default way of listening to songs. But fast forward to today and both bandwidth and storage capabilities have made exponential leaps forward. Indeed, broadband and cellular speeds now make streaming or downloading large files nearly instantaneous (though if you are on a data capped cellular plan, downloading this type of huge music file could quickly eat through your monthly allotment). Storage, meanwhile, is a fraction of the cost it used to be or even free with other cloud services. Those shifts have enabled streaming services to make the dream of audiophiles to come true: abandon lossy compression and offer HD or even Hi-res quality options to everyone.

Limitations remain for finding true Hi-res Audio

While that lossy approach is clearly great for file size, it does come at the expense of audio quality and robustness to further processing. For consumers looking for the absolute best audio experience, there are, a few critical wrinkles and limitations to consider.

To begin with, keep in mind that lossless audio and Hi-res audio are not interchangeable terms. Again, lossless simply denotes that no detail has been removed from the original. And that in turn means that the moment of creation matters and the source material itself therefore acts as the first limiting factor to enjoying hi-res audio. If the original is in CD quality, for instance, the lossless audio will also be delivered at CD quality. To find lossless audio that is HD or hi-res, the original needs to have been created at a bitrate equal to or greater than those formats. To some extent, this is happening via the remastering of older recordings, but the resolution is still defined by the original recording. Fortunately, over the last few years an abundance of new recordings are being made at higher resolutions. Still, keep in mind that hi resolution audio is not necessarily lossless. The Hi Res Japanese Audio Society (JAS) standard is 24bit /96kHz, but is still a lossy format.

But capturing hi-res in the recording process is only the first step. Your streaming or download service is the second limiting factor. It must actually transmit or deliver material at that same advanced bitrate. As mentioned above, the good news is that there are now several services that support hi-res and many of them no longer charge extra for that higher quality. Indeed, this is one of the interesting outgrowths of Apple's entry into the lossless and hi-res category. Amazon Music HD and Ultra HD (up to the 24-bit, 96-192kHz standard of hi-res) are now offered free of charge to users. But there's an important caveat: if you want hi-res Audio, you'll need to make sure that you have updated the settings in your preferred streaming service to deliver content at that advanced bitrate.

One final limitation must be overcome to assure you are actually enjoying lossless and hi-res audio: reception at your device, wired headphones, and/or wireless earbuds. Let's start with those who prefer a wired listening option. Here's where things (for the moment) get a bit odd within

the Apple ecosystem. The digital-to-analog converter (DAC) that Apple uses doesn't support hi-res audio. That means that at the device level even the best, newest iPhone and MacBook do not yet support native playback at a hi-res bitrate. Instead, playback maxes out at HD quality (24-bit, 48kHz). That's a huge jump from AAC quality, but it's not true hi-res. If you want to listen to hi-res audio with wired headphones, you'll need an external, hi-res enabled DAC. That might deliver the highest, truest audio quality, but it's clearly not a streamlined solution and runs counter to today's push for a wireless audio experience.

Bluetooth and On-the-Go Audio

That last critical step to enjoying hi-res audio is further complicated by the growing desire to be free from wires. Bluetooth has revolutionized how we listen to content and, for many people, has made a wired audio connection a relic. Bluetooth acts as the "last mile" of delivery and it's this last step that can undercut the entire lossless and hi-res process. Unfortunately, thanks to its inherent bandwidth and codec (coder-decoder used to reduce raw bit bandwidth requirements) limitations, Bluetooth cannot currently deliver lossless audio: all Bluetooth connections to date employ lossy compression based on psychoacoustic masking techniques and while bit-rate efficient, more audio data is lost.

Traditionally Bluetooth downsamples and compresses content to the max that a provider's Bluetooth codec allows. That means that even if the source material was recorded in hi-res, and even if your streaming service can deliver that same hi-res quality, the listener has ultimately been limited by the Bluetooth codec when choosing wireless audio.

What differentiates Qualcomm's aptX technology from regular Bluetooth codecs is that aptX is based on ADPCM (Advanced Pulse Code Modulation) techniques and is a non-destructive codec, this means that the post-processed audio is very similar to the original uncompressed file

Your best wireless option for Hi-res audio

To enjoy the highest quality audio with a wireless connection, your best bet is to search for earbuds that take advantage of Snapdragon Sound technology, which offers high-performance codecs specifically architected to deliver better sounding audio. Snapdragon Sound utilizes the aptX Adaptive codec which can deliver high resolution 24-bit 96kHz , and provides a dynamic bitrate and bit-error resilience to help deliver a top-notch, immersive audio experience even under crowded RF conditions or during variations in the content itself. Qualcomm has also recently announced their intention to support aptX Adaptive scaling all the way to lossless CD resolution over Bluetooth with Snapdragon Sound. To do this, Qualcomm has taken an integrated approach between the source and sink devices, the codec itself, and optimized software end-to-end in order to deliver the needed data throughput.

Even better for those in the Android ecosystem, Qualcomm offers a robust certification and testing program to assure that the high-quality audio you expect is delivered by all of its partners.

Look through Qualcomm's partner list and you'll find top names across the audio industry, including Audio Technica, Bang and Olufsen, Beyerdynamic, Bose, Bowers and Wilkens, Jabra, Logitech, Sennheiser, and Shure, among others.

Putting It All Together

In short, the increasingly cheap cost of storage plus a vast increase in speed and bandwidth has enabled a new interest in lossless, hi-res audio that overturns the old MP3 and AAC experience and promises new access to an immersive audio experience to millions of users. But even though storage space and bandwidth have largely been removed as limiting factors, the demand for wireless audio itself brings new complications.

Achieving true hi-res audio requires more than simply finding a service that offers lossless (FLAC or ALAC) streaming. Rather, you need to assure your audio as part of a full end-to-end solution, and for those interested in a wireless solution, not all Bluetooth solutions are created equal.

Indeed, Qualcomm is the only provider that is working across the entire ecosystem to support complete solutions for developers and for consumers that deliver not just a wireless experience of CD-resolution lossless audio but audio of even higher resolution than that, all in a format closest to the hi-res audio standards while also attending to challenges of robustness and latency

In short, if you want wireless hi-res or lossless sound, finding a music player or smartphone and earbuds that take advantage of Qualcomm aptX HD, aptX Adaptive, or Snapdragon Sound should be your highest priority.