Ultimate Guide To Audio Bitrate & Audio Formats

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From the very first time that humans have been able to record sounds, we have wanted to share those recordings with the world. With the explosion of modern technology, we are now constantly surrounded by sound. From our mobile phones to TVs to the music we play. But how much do you really know about the sound you are hearing? In this guide, we cover how sound works in the modern age and give you a definitive outlook on how you can enjoy sound more.

What Is Audio Bitrate

Audio bitrate defines the amount of data that is stored in the sound file you are listening to. Every audio file has a "bitrate" associated with it. Every second of an audio recording contains a certain amount of data or bits. When it comes to sound files this is calculated by the number of kilobits of data per second. For example, a 128 kbps (kilobits per second) file will have 128 kilobits stored for every second of audio.

The more kilobytes that are stored per second the higher the sound quality of the file. For the average listener, the quality will be defined by the strength and depth of low frequencies. It will also be defined by the crispness and clarity of high frequencies. More kilobits equals more data stored across the full frequency range.

Now let's look at some common files you'll likely have encountered and dive into the details of their respective audio bitrates.

CD Audio Bitrate

CDs have a bitrate of 1,411 kbps at 16 bit. This was first established by Philips and Sony all the way back in 1980. After a few discussions on details, it was adopted as a standard in 1987. From there CDs rapidly replaced compact cassettes as the standard for the sale and distribution of audio recordings. But, the dominance of CDs has declined. The general trend has moved towards internet-based music distribution methods.

Once the dominant force in music distribution CD's are now on the decline.

WAV Audio Bitrate

WAV files were developed by Microsoft and IBM. Apple also developed their own version, AIFF files, using the same technology. Both file formats offer uncompressed high-quality audio files.

High-quality WAV files have an audio bitrate exactly the same as CDs at 1,411 kbps at 16 bit. But that isn't the end of the story for WAV files. There are variations. The actual bitrate is determined by a specific formula which multiplies the sampling rate with the bit depth and the number of channels.

MP3 Audio Bitrate

The highest quality MP3 bitrate is 320 kbps at 16 bit. You can encode MP3s as low as 96 kbps. MP3s use a compression codec that removes frequencies while trying to preserve as much of the original recording as possible. This does result in a reduction in sound quality but also a big reduction in file size. MP3s became extremely popular in the early days of the internet due to their low file size. It made them easier to share across slow internet connections. They are still used heavily by streaming services and digital music platforms.

24 Bit VS 16 Bit

You may have noticed a pattern above when covering bitrates. All the sources mentioned are at 16 bit. But there are audio files that are at 24 Bit. There has been much debate about whether the difference between the two is really that important.

To understand the battle between 24 Bit and 16 Bit we need to cover how sound functions and more importantly how we hear that sound. Audio bitrate is usually the primary way to determine the sound quality of files but there is more to it than meets the eye…..or should I say ear.

Bitrate is determined by the sampling rate and the bit depth. The sampling rate is the number of samples taken in a second. For example, CDs have a sampling rate of 44.1kHz. This all stems from the groundwork laid out in the Nyquist–Shannon theorem. This theorem determined th you double the maximum frequency of the source you can accurately capture the sample. The human hearing range tops out at about 20kHz. By doubling that you can assume that nothing relevant is lost when recording/reproducing the original sound. Nothing that you would realistically hear.

This hasn't stopped people from recording at a higher sampling rate. Hi-resolution audio can be recorded at double the standard CD rate or even as high as 192kHz. The question often comes up if this is needed. There are instances where a higher sampling rate does help to improve the listening experience. Analog to digital converters have an in-built low pass filter. This filter processes out frequencies that are not within the sampling limit. For example, if the sampling rate is 44.1kHz anything below half that will be accurately rendered. Anything above that will introduce fake samples which is where the low-pass filter kicks in to process them out. By increasing the sampling rate you move the low-pass filter higher into the frequency range. This moves it further from our hearing range resulting in cleaner sounding audio.

The second component is bit depth. Bit depth is the number of bits available to capture sound. For each extra bit beyond the first the accuracy and number of bits doubles. Each bit is a slice of the sound you are hearing. The more bits available the greater options in the information that can be stored. The end result is greater accuracy in hearing subtle details which might be lost at lower bit depth. With 16-bit audio, there are 65,536 possible levels that can be captured. 24-bit audio has the capacity of 16,777,216 possible levels.

To help visualize the difference imagine if you were watching a movie and you only got to see every 10th second of the image. You would still be able to get an idea of what was going on but you would miss out on the subtle changes in the movement of the actors on screen. If you then got to watch every 3rd second you would have a greater sense of their movement. Bit depth works the same way allowing more refined detail to be captured.

What Is The Best Audio Bitrate?

When it comes to audio bitrate size does matter. The more kilobits per second the greater the quality of the sound. For most general listening 320kbps is ideal. Of course, CD-quality audio that stretches to 1,411kbps will sound better.

To determine the best audio bitrate you need to also assess your needs. If storage space is a concern high bitrate files will rapidly eat into your available space. For example, an MP3 file at 128kbps will take up approximately 1mb of space per minute of audio. A 320kbps MP3 file will take up about 2.4mb of space per minute. Meanwhile uncompressed CD audio will take about 10.6mb per minute.

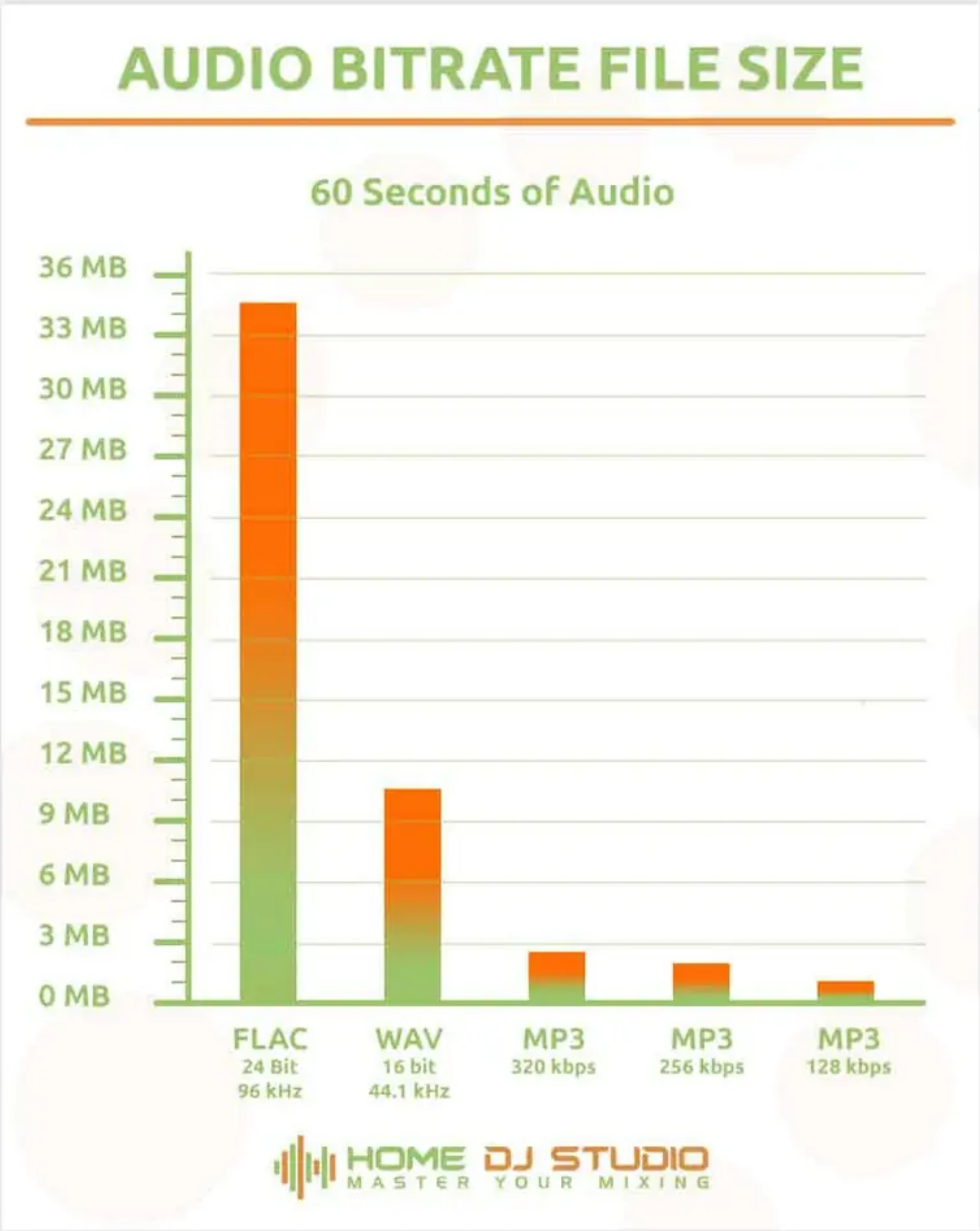
If you have space go for the highest quality bitrate possible. You can always convert down to smaller files sizes but there is no way to convert back up to higher quality.

There are situations where higher bitrates are not ideal. Streaming services like Spotify need to be able to deliver data efficiently without lag or delay. As a result, many streaming services have lower bitrate audio quality. YouTube audio streams AAC files at 126kbps. While perfect for fast delivery it isn’t great for audio quality.

So while there is no definitive answer with today’s large hard drives you should aim to get files at the highest bitrate possible.

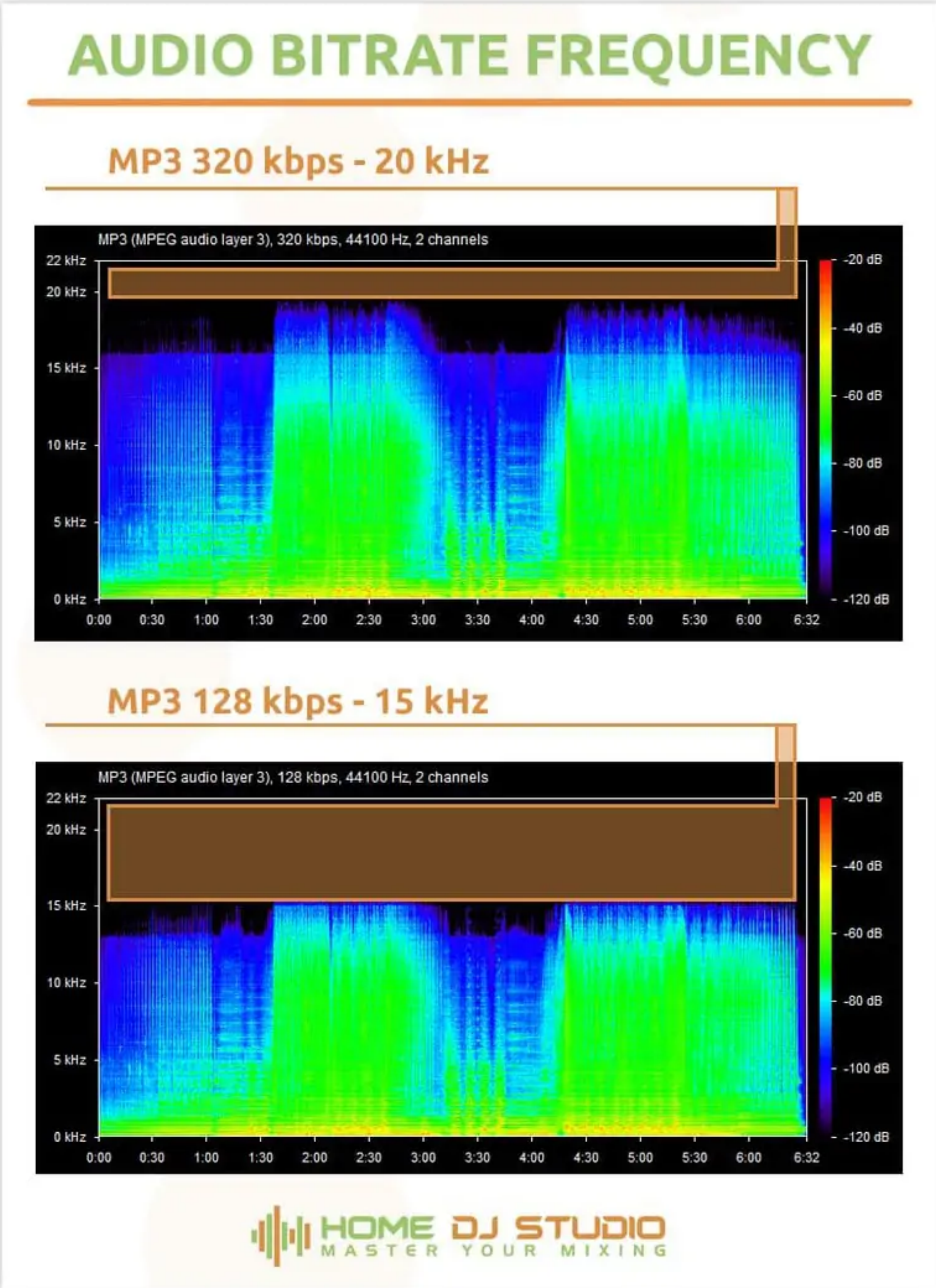
Audio Bitrate Comparison

Lower audio bitrates achieve smaller file sizes by compressing the source file. Below you’ll find a table that covers the difference in file sizes across various bitrates.



Higher quality audio bitrates result in much higher file sizes.

Unfortunately, this compression also results in a loss of quality. The images below highlights the audio frequency cut off point for a 320kbps MP3 compared to a 128kps file.



The lower the bitrate of an MP3 the more data is removed from the source.

Audio Bitrate Test

All these graphs and waveforms images do not compare to the real thing. At the end of the day, the true judge of quality is our own ears. Quality is also affected by what you are listening to the sound on. Budget DJ speakers will also produce poor quality audio even with the best bitrates. Invest in quality DJ speakers if you want the best results. Even a pair of high-quality studio monitors can make a huge difference when it comes to your perception and understanding of audio quality. Below you'll find 3 examples of an audio file at different bitrates. Have a listen for yourself and see if you can hear the differences.

0:00 / 0:35

CD Quality WAV File – 1,411 kbps

0:00 / 0:35

High Quality MP3 File – 320 kbps

0:00 / 0:35

Low Quality MP3 File – 128 kbps

0:00 / 0:35

Very Low Quality MP3 File – 32 kbps

What Is Hi-Resolution Audio?

As technology continues to improve, so does the potential to deliver better quality audio. Even streaming services like Spotify that have relied on smaller bitrates are now offering higher quality audio. The term hi-resolution or HD audio gets thrown around a lot but what does it actually offer?

HD audio is usually associated with any audio that is of greater quality than CD. It's as close to the original source file or what the musicians in the studio were recording as it gets.

These files are not as new as you may think. In fact, HD audio has been around as far back as 1995 but couldn't find a foothold in the market at the time. With the growth of 4K and 8K TVs, it was only a matter of time before we wanted the quality of the audio to match the quality of the video. Higher internet speeds have also made it easier to be able to stream these large files.

These lossless audio files have a higher sampling rate and greater bit depth. The higher sampling rate results in less fake samples making their way into an average person's hearing range. The bit depth allows for greater nuances to be captured. The end result is a cleaner sound.

The question remains whether we can actually hear the difference. Blind test studies have shown that for most people they cannot tell the difference when compared to CD quality audio.

There is no need to be rushing out to get HD audio files as you'll likely not notice the difference. But knowing that the audio you are listening to is as close to the original recording as possible does offer a sense of security.

Audio Formats

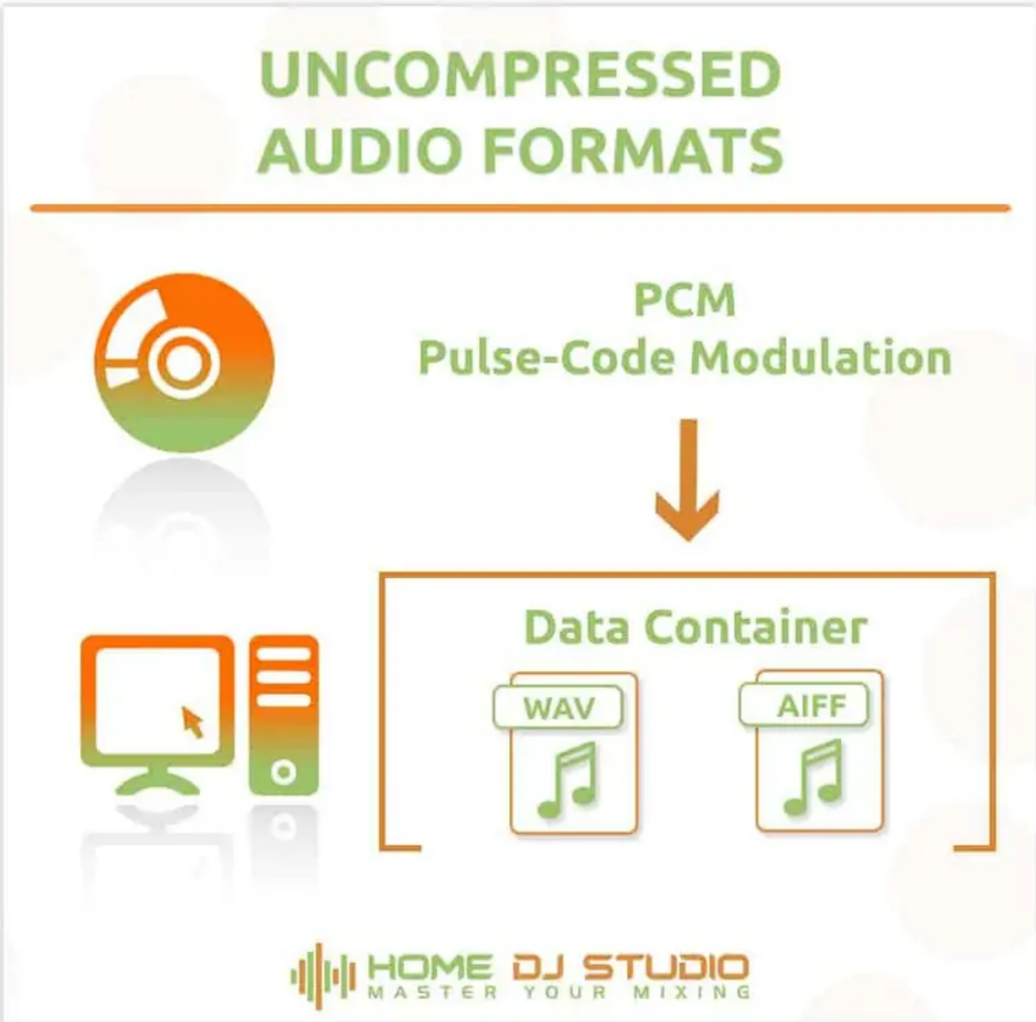
There is a large range of audio formats that are commonly used today. But all audio formats fall into two major categories. Uncompressed audio formats and compressed audio formats.

Uncompressed Audio Formats

Uncompressed audio formats capture the original recording without any further modifications. They take the soundwaves and convert them into digital format. These formats do offer maximum quality but it does result in much larger file sizes. This can make some of them unsuitable for streaming on slower internet connections. Below are some of the most commonly used uncompressed audio formats.

PCM

PCM or Pulse-Code Modulation is the overarching format for uncompressed audio. All recordings begin their life as soundwaves in an analog setting. PCM converts this information into digital format by sampling that recording. Sampling rate and bit depth are used to sample the recording. The sampling rate defines how many samples are taken per second. Bit depth refers to the number of bits that are allocated to each sample. You can learn more about sampling rates and bit depth in our 24-bit VS 16-bit section above. This file format is the main format for audio files that are located on CDs and DVDs.



WAV and AIFF files are a container for PCM data.

WAV

Many of you will likely be familiar with this popular uncompressed format. Developed by IBM and Microsoft it is essentially just a way for PCs to read PCM data. While WAV is primarily used for high-quality audio by definition a WAV file can still contain lower quality audio bitrates. It all depends on the original source.

AIFF

Much like WAV files AIFF files are another way for electronic devices to read PCM data. In this case, it was developed by Apple to use on their systems. Likewise, they can also contain lower quality audio bitrates.

Compressed Audio Formats

There are two main subcategories of compressed audio formats. Lossless audio formats and lossy audio formats. Each offers some benefits depending on their intended application.

Lossless Audio Formats

Lossless audio formats keep all the original recording data and compress that data to reduce file sizes. Below are some of the most common lossless audio formats.

FLAC

They say the best things in life are free. FLAC or Free Lossless Audio Codec is an open source compression method for audio files. The original recording is left untouched yet the file size is reduced by up to 60% compared to the original raw file. Without licensing restrictions, it has grown in popularity as the main way to offer compressed lossless audio. FLAC also offers extra metadata to be stored like Album art which WAV files do not support.

ALAC

Apple also threw its hat into the compressed audio format space with its own file format ALAC. Offering compression similar but not as great as FLAC it is still widely used today. This is due to iOS and Apple systems not supporting FLAC files. While this may sound restrictive you can convert between the two formats with free tools available online.

WMA Lossless

Microsoft also has its own lossless format but it isn't open source. WMA (Windows Media Audio) lossless used a different compression method. This method allows for the file to be uncompressed back to its original state without any degradation of quality or loss of data. It can also support hi-resolution 24-bit audio. While this lossless format was designed for archival applications it is supported by a range of consumer devices.

Lossy Audio Formats

Lossy formats aim to reduce the file sizes of audio files as much as possible. To achieve this the data is consolidated and some data discarded. Depending on the level of compression this can result is a noticeable decline in quality. Below are some of the most common lossy audio formats.

MP3

The most well known of lossy formats is MP3. A format that revolutionized the music industry and the way we listen to music. MP3 (MPEG-1 Audio Layer 3) aggressively reduces file sizes by cutting data that is deemed unnecessary. Anything outside of the normal human hearing range is discarded. On top of that, it degrades the quality of difficult to hear frequencies and then consolidates as much of the remaining data as possible.

Offering flexibility to compress at various bitrates made it a good choice at the start of the internet boom. The smaller file sizes also allowed the files to be quickly transferred across the internet. This led to a massive spike in music piracy.

It is still one of the most widely supported audio file formats. But with the increase in internet speeds and hard drive capacities, its popularity is on the decline. Streaming and downloading higher quality files is now a viable alternative.

Portable MP3 players helped drive the popularity of the MP3 file format.

Ogg Vorbis

Ogg Vorbis is an open source compression format. Unlike FLAC and ALAC it is not as widely used. This format is actually made up of two components. The Vorbis side is actually the compression component while the Ogg side is a container to hold that data. While an effective compression method it has not been adopted or supported by as many devices as its competitors. But, if you're looking for something that is open-source it is your best bet.

AAC

AAC (Advanced Audio Coding) may not be as well known as MP3 but it plays a massive role in our modern lives. Designed as a better alternative to MP3 it achieves better sound quality compared to MP3 at the same bitrates. It achieves this by offering greater sampling rates (8 to 96 kHz) compared to MP3 (16 to 48 kHz). It can also handle up to 48 channels compared to 2 for MP3. As a result, it is widely used by Youtube, Nintendo and Apple to name a few.

How Does Audio Compression Work?

With the vast adoption of compressed audio formats, it's worth looking into what these compression methods actually do.

Audio compression has one primary goal, to reduce the file size of the source material. This is like how image files are compressed into .gif and .jpeg files to reduce the file size. This makes the files quicker to download.

This was especially important in the early days of the internet. Speeds were as low as 56K meaning CD-quality audio files would take hours to download.

All compressed audio formats take advantage of the limitations of human hearing to help determine how to compress the file. This type of compression algorithm is called perceptual noise shaping. It uses the discoveries in Psychoacoustics (the study of human hearing) to make changes to the source material. It also aims to minimize the impact on what is perceived by the listener. The end result is near CD quality sounding audio without the bulky file size.

Like image compression, audio compression aims to retain as much data as possible in a smaller file size.

There are a few major elements that form the fundamentals of audio compression algorithms.

The first one applies to the minimum audition threshold of the human ear. Our ears are most sensitive to frequencies in the 1-5 kHz range. The further you stray beyond this range the less sensitive we are to the sound. While most people can hear up to about 20 kHz it is only remotely perceptible. The rough cut off is about 16 kHz. Audio compression uses this information to eliminate any content deemed outside of the human hearing range.

The second step involves Temporal Masking. This takes advantage of another trait of human hearing to remove even more data from the source material. There can be many sounds playing at the same time, or very close to each other. In this situation, we will naturally hear the louder sound and often disregard the softer sound. The greater the difference between volume levels the more this takes place. Audio compression uses this to find sections of softer sound data located near louder sounds. It then removes the softer sounds as it is likely the human ear will not perceive them.

The next step is another form of masking known as Simultaneous Masking. How we hear sound is split into distinct critical bands. Each band is made up of a certain frequency range. If there happens to be a loud sound within one of those ranges it can spill over into other frequencies. This will make soft sounds in those frequencies far less distinct. Once again audio compression algorithms aim to identify these sections and eliminate that data.

These steps allow the file size to be reduced by up to 10 times but there are drawbacks. The lower the bitrate of the file the more aggressive the algorithm is in trying to find components to remove. This can result in loss of audio quality, especially among lower bitrates like 128kbps and below. Unfortunately, many streaming services deliver audio at these levels which is equal to what you would hear on the radio.

The end result can lead to some common issues and changes that were not intended by the artists creating the music. Most notable is the lack of definition and oomph in the lower frequencies where bass tends to live. Clarity and definition can also be lost at other frequencies. For example, a hi-hat that is meant to play a prominent role may sound flat and fall behind other components of the song like vocals.

There is no denying that audio compression is a testament to human ingenuity. It helped pave the way for the internet to handle audio in a reliable and efficient way. But likewise, there is no denying that there are issues with the end result, especially at lower bitrate levels.

What Is The Best Audio Format?

While there are benefits for all audio formats FLAC is one of the best audio formats currently available. It offers high-quality audio without the burden of large file sizes. Coupled with its popularity as an open source format cements it as the current best choice.

Having said that there is an argument for lossy formats like MP3 and AAC. In an environment where data transfer rates are important, they do outshine lossless audio formats.

For audiophiles, you can't go past Hi-Resolution audio formats like WAV and AIFF, even if it's debatable if you can even hear the difference.

As you can see it all boils down to application and feel. Need reasonable quality streaming with small file sizes…stick to MP3 and AAC. Want the purest closest representation of the original material…..stick to WAV or AIFF. But, if you want that nice in-between marriage of quality and size go with FLAC.

Audio Formats Comparison

With so many file formats available it can be difficult to compare. Below is a quick summary of the most popular audio file formats and the features they offer.

AUDIO FILE FORMATS

	Sample Rate	Bitrate	Type	Open Source	Supports Metadata
WAV	Usually 44.1 kHz	Usually 1,411 kbps	Lossless	No	No
AIFF	Usually 44.1 kHz	Usually 1,411 kbps	Lossless	No	Yes
FLAC	Up to 655,350 Hz	Usually 1,411 kbps	Lossless	Yes	Yes
ALAC	Up to 384,000 Hz	Usually 1,411 kbps	Lossless	Yes	Limited to iTunes
WMA	Up to 96 kHz	Up to 768 kbps	Lossless	No	Yes
MP3	Up to 48 kHz	Up to 320 kbps	Lossy	Yes	Yes
OGG	Up to 192 kHz	Up to 500 kbps	Lossy	Yes	Yes
ACC	Up to 96 kHz	Up to 529 kbps	Lossy	No	Yes

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There is plenty of variation and choice between audio file formats.

MP3 Is Dead

MP3s have gone hand in hand with our perception of audio file formats. It's difficult to imagine them going the way of compact cassettes. But that future is closer than you may think.

Internet speeds continue to increase by leaps and bounds. The US alone saw a 37% improvement in internet speeds from November 2017 to December 2018. The increased access to faster speeds reduces the need for compressed audio formats compared to the '90s where MP3 dominated.

Additionally, consumers are becoming more conscious of quality improvements with the adoption of HD video and now 4 and 8K video. That desire for quality is transferring to audio quality as well.

Lossy formats still have a role to play in developing countries with slower internet. These formats are also very effective at delivering audio where quality is not the greatest concern. As a result, they are still a popular choice for streaming services looking to deliver content quickly. They are also a popular choice for speech-based podcasts where the frequency demands are not as pronounced.

But it is only a matter of time before the MP3 audio format will become a relic of a time gone by. Let's check out how MP3's stack up to other popular formats to see if this format still has something to offer.

CD VS MP3

CD quality audio is the most widely accepted standard for high-quality audio. WAV and AIFF files offer excellent sound quality. While 320kbps MP3s provide good quality audio it will always be outdone by CD quality audio. Where MP3s shine is in file size. MP3s can reduce file sizes of CD audio files by up to 10 times if using 128kbps compression.

FLAC VS MP3

FLAC offers compression without the quality loss of MP3s. With FLAC files you preserve quality but reduce CD audio file sizes by up to 50%. Leaving the original audio intact leaves MP3 as a poor option if hard drive space or streaming speed is not a concern.

AAC VS MP3

If you want high-quality audio but still want to reduce file sizes AAC is a better choice than MP3. The more advanced successor to MP3 encodes frequencies beyond the MP3 cutoff of 20 kHz. While a better compression format, it wasn't as widely adopted as MP3. As a result, not as many media devices support AAC. If compatibility is a primary concern MP3 may still be a better choice.

It's Just The Beginning

So much has changed over the last two decades when it comes to audio formats. While the rate of change has slowed manufacturers are continuing to push the boundaries to convince us that we need the next best thing. There is a natural barrier to human hearing so future developments will have to lean on other angles to entice consumers. I'd like to think that we have reached the pinnacle of audio formats but it would be naive to not imagine further change. As the way we consume media evolves so will audio formats.

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Robert Calabrese

I've loved electronic music since the age of 12. From listening to tapes on my walkman, buying CD's and now in digital format. As the music evolved so has my experience and I'm passionate about sharing my journey with you.

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Home DJ Studio focuses on teaching aspiring home DJ's how to choose the right equipment and develop their DJing skills. We have over 20 years' experience in the industry and a pure passion for what we do.

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