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Tech Tip: Sample Rate and Bit Depth—An Introduction to Sampling

Posted on Wednesday, 23 July 2014 15:32.

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If you've ever pondered the specs for digital audio and weren't quite sure what numbers like 16-bit/44.1kHz really mean, this tutorial will give you the information you need to understand the basics of digital audio.

Analog to digital

To enable computers and hard disk recorders to record and edit sounds, those sounds have to be digitized—broken up into the 1s and 0s that make up the binary world of computers. Much like a movie is a series of individual still frames that are interpreted by our brains as a continuous image, digitized audio is a series of "snapshots" that we hear as continuous sound.

Sample rate

How often these audio snapshots are taken is referred to as the sample rate. The more snapshots taken, the more detail the sound has. These pictures illustrate how sampling works:

Figure 1 - sine wave

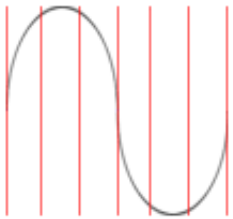

Figure 2 - low sample rate

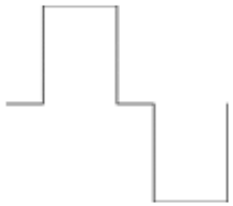

Figure 3 - resulting waveform

Let's assign the sine wave in Figure 1 a frequency of one cycle per second—far too low to hear but great for illustration purposes! Figure 2 represents the sample rate—in this case six samples per second, or 6Hz. Each red line represents a snapshot of the sine wave at that single moment in time. When you combine the snapshots, they will look like Figure 3. There's not much resemblance to a sine wave! In fact, if you were to increase the

frequency of these waveforms to an audible pitch, the tonal difference would be amazing—the sine wave would be soft and dull, while Figure 3's waveform would sound bright and piercing.

To get a better representation of a sine wave, we need to increase the sample rate. If we change the rate from 6Hz to 10Hz, we get a much better result:

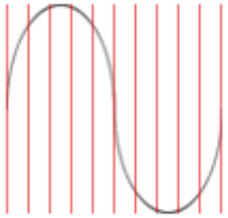

Figure 4 - higher sample rate

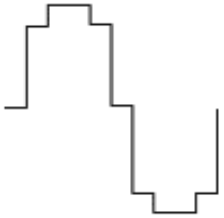

Figure 5- resulting waveform

As you can see, even though the sample is still pretty chunky, it's a lot closer than the first example! Obviously, the more samples per second, the more the resulting waveform resembles the original.

At one time, the most common sample rates in digital recording were 44.1kHz and 48kHz—both significantly faster than our examples above! But with the falling cost of storage, much faster computer processors, and greatly improved analog to digital converters, sample rates of 96kHz-192kHz are now the standard for pro-level audio. The higher the sample rate, the greater the bandwidth or frequency response.

If more is better, why not sample everything at a super-high rate? In addition to the higher cost of fast converters, there's the cost of memory and disk space to consider. A sound sampled at a rate of 192kHz will eat up four times as much disk space as that same sound sampled at 48kHz. With the bargain prices of external hard drives and other storage devices, though, this isn't the huge barrier it used to be.

Bit depth

The other part of the digital audio equation is bit depth. Much like the sample rate defines the frequency response as it divides up the horizontal axis of the waveform, the bit depth defines the dynamic range of the sound as it describes the amplitude of the waveform at each sample point. 8-bit audio gives you 256 separate levels for each sample. 16-bit audio gives you up to 65,536 levels, and 24-bit samples give you 16.7 million different levels! Let's look at this a little more simply:

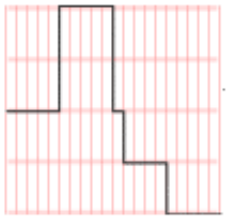

Figure 6 - low bit depth

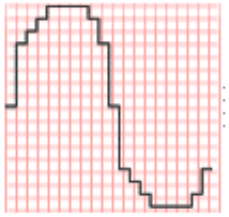

Figure 7 - higher bit depth

Figure 7 has twice the sample rate described in Figure 4, yet the waveform looks more like a brick wall than a sine wave! That's because the low bit depth offers very little in terms of dynamic resolution. The higher bit depth shown in Figure 7 results in significantly improved waveform resolution.

Put 'em together

When you're recording, it is generally best to record at the highest combination possible. You can always down-sample for your CD master, but the more data you start out with, the better your final mix will sound. Plus, in the future, you will be able to remix your stuff at the higher rates as they become the new standards!

To learn more, read our Recording Gear Buying Guide.

Explore the huge selection of recording gear at Musician's Friend.

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