HIGH RESOLUTION AUDIO

When it comes to your computer monitor, the term high-resolution is easy to understand. 1,600 by 1,200 pixels on the screen have a lot finer detail than the old 640 by 480. 24-bit color has millions of shades, where primitive color PC displays had only a total of 16 colors...

Audio, be it for music, music videos or movies, can benefit from high-resolution also. Digital audio has higher or lower resolution too, though the difference is a little harder to explain. We'll go though it here and soon you'll be the expert on high-resolution audio in your crowd

1. Audio Before Digital

The old analog audio recording industry was full of different formats with all different sizes of discs and recording speeds of 33 1/3, 45 and 78 RPM. We had tons of gadgets to clean our records and rid our sound of the clicks and pops that dust causes. Getting an LP out of the cover, on to the turntable, and the tone arm lowered onto the disc without scratching it was a high art.

Audiotape came in reel-to-reel, 8-track and audiocassette, again with different recording speeds and an alphabet soup of noise reduction schemes like Dolby-A, B, C, S and HX Pro. Dust that flaked off the tape would gum up the transport mechanism and the tape would jam, usually destroying the sound quality for that piece of tape.

Unfortunately, music signals in an analog form are subject to all sorts of degradation. Electrical circuits introduce noise and hum. The recording medium itself will roll off the high frequencies or introduce variation in the pitch. Magnetic tape is especially bad at distorting the signal and adding noise, which is why Mr. Dolby got very rich with his noise reduction tricks. Digital audio avoids all this, but of course there are other issues to deal with.

2. Compact Disc, the Audio Standard

Researchers at Philips had been working with optical discs for recording movies for some time when they shifted their attention to an audio-only disc. At first, they tried analog recording methods like their video discs, but finally decided to use PCM, a digital audio format previously used for long distance telephone links. PCM stands for Pulse Code Modulation, a very simple digital system where the audio is sampled at a constant rate and the samples represented by digital numbers. There is no compression, just the raw samples.

Phillps brought Sony on board and they put together the digital audio standard that is still the most-used audio format for commercial music sales. They called it the Compact Disc, which we all shorten to CD. Since straight PCM is used, they picked the format to squeeze as much music as possible on the disc while maintaining adequate fidelity.

3. Sampling Theory

In order to understand digital audio specifications, we'll have to define digital sampling theory. The most basic thing we need to get under our belt is the concept of converting analog music signals into digital. That's called sampling. The electrical signal that represents music is a nice smooth wave that follows the sound pressure waves that come from a singer, or an instrument, or the combination of both.

4. Breaking Up Is So Hard to Do

If we use an analog meter to follow the music signal, the needle would swing smoothly back and forth with the rise and fall of the waves. What if we use a digital meter and quickly write down the numbers, in essence, taking many numerical samples of the waveform? It turns out that if we take samples at a high rate, the mass of numbers will accurately represent the audio waveform.

How fast is that rate? A researcher named Nyquist figured out that if the sampling rate were at least twice as high as the highest frequency signal to be digitized, then the sampled digital signal would accurately represent the analog signal. Since the highest frequency most human ears can hear is 20 Kilohertz, the designers of the Compact Disc decided to use a sampling rate of 44.1 Kilohertz.

Though theoretically they could have used 40 Kilohertz, there are some practical problems that require filtering, and they need a little room for the filter roll-off, so they selected 44.1 Kilohertz. We'll get back to this issue of the filters and picking a sample rate that is just barely enough.

5. All the little pieces

Compact Discs have just barely enough sampling rate to capture the entire audio spectrum. The other issue is the number of bits of resolution to represent the amplitude of the signal. If

you only listen to AM radio where the music is loud all the time, you would happy with very few bits in your audio samples. But, if you want to listen to exciting music that is loud sometimes and very soft when it needs to be, then you want more detailed samples, which means more bits.

At the time the CD was being designed, the audiocassette was one of the most popular recorded music formats. The ratio of the loudest music to the softest was about 45 decibels, or dB. That's more than a factor of 20,000 from the lowest to the highest amplitude, which seems like a lot, but the human ear has an amazing ability to discern a huge range of loudness. Even in a noisy car, the dynamic range heard on cassettes, or ratio of softest to loudest, bothers me. There was just too much hiss. The best noise reduction (Dolby and others) managed to stretch the dynamic range to 60 or 65 dB, up a factor of 100 and a great improvement, but when stopped at a traffic light, the hiss was still evident.

The PCM audio encoding that the Compact Disc designers copied could achieve a 35 dB dynamic range with only eight bits of resolution. But, they played tricks with the bit values to stretch the dynamic range at the expense of fidelity. Since 35 dB was obviously not enough, and digital circuits like to come in multiples of 8, the designers picked the next increment up, that being 16 bits. With 16 bits of equal step size, they had 96 dB of dynamic range, which at the time was much better than any other recording medium, including the professional analog tape decks in recording studios.

6. The Bad Old Days

In 1982 when the CD was introduced, we were used to the hiss of magnetic tape and the clicks and pops of LP gramophone records. The CD was such a huge improvement that we assumed that it was perfect. Many young people today have never even heard an LP played, so CD digital music is their frame of reference. It's far better than what we used to have, but it is still not even close to perfect.

7. Higher Expectations

Why would we want a higher sampling frequency than 44.1 Kilohertz and more than 16 bits of dynamic range? Because we are crazy about absolutely perfect sound! More and more we listen through earphones or 100 Watt car stereo systems where the noise floor of 16 bit audio is bothersome and the harshness of the sharp cutoff filters for the 44.1 Kilohertz sampling irks us.

The dynamic range is pretty easy to understand, with the background noise level very low and the loud peaks very high. But, the sampling rate/cutoff filter thing takes a little more explanation. We are trying to record the audio spectrum from 20 Hertz to 20 Kilohertz with a sampling rate of only 44.1 Kilohertz. That means during recording, signals above 20 Kilohertz have to be sharply attenuated or they end up causing digital artifacts down in the audible portion of the frequency band. In fact, many commercial CDs roll off most sounds above 15 Kilohertz to avoid the

distortions of the cutoff filters.

On playback, you have a similar situation with filtering at the band edge. There are filters that can do the sharp cutoff, but a side effect of the sharp filters is phase shifts where different audible frequencies are delayed more than others. The effect is harshness to the sound that is hard to pinpoint, or even to measure with simple instruments, though sophisticated lab equipment can show it exists.

8. Six is More than Two

In addition to our increased demand as consumers for higher quality audio, with many of us having at least some kind of basic home theater setup, we've also become accustomed to the immersive audio experience of "surround sound," or sound presented over more than just two (stereo) "discrete" (individual, independent) channels. Recording engineers and record producers experimented with quadraphonic, or four-channel, sound in the 60's and 70's, but it required expensive, specialized equipment on both the recording (studio) and especially playback (consumer) ends, and never really caught on.

While Compact Discs offered audio quality better than anything previously available, because of technological limitations, there was only so much data (music) you could fit on a single disc, limiting developers to two-channel, stereo audio.

With the advent and rapid consumer adoption of DVD, all of that changed. Because of the huge increase in the amount of data that can be squeezed onto a single disc (up to 8.5 Gigabytes now on one Double Layer DVD, compared to ~700 Megabytes on a CD), there's room for not only lots of high-resolution video and high-fidelity audio, there's room for several more discrete audio channels, as well – as many as six or more.
A typical "5.1" home theater surround sound configuration includes two stereo channels (front sides), a center channel, two rear side channels, and a dedicated LFE (Low Frequency Encoding, or subwoofer) channel (the ".1").

Because of this, some artists are beginning to consider mere CD quality, stereo recordings as "giveaway-quality" audio, and are releasing new music on DVDs encoded with audiophile-preferred "dts" (Digital Theater System) digital 5.1 surround sound.

9. More and Faster

The solution to problems with phase shifts and distortion is simple: more bits of resolution to produce more dynamic range and a higher sampling rate to avoid the sharp filters required by a low sampling rate. The Creative Sound Blaster X-Fi Fatal1ty FPS PCI Sound Card is a perfect example of high-end, high-resolution audio equipment for your computer. It has state-of-the-art 24-bit data paths for a dynamic range of 109 dB, 13 dB better than the 96 dB of CD audio. Since dB is a logarithmic scale, 13 dB translates into a noise floor 20 times lower.

The sampling rate has been cranked to 192 Kilohertz, which allows for a very simple and non-distorting cutoff filter. For those with younger ears that can hear past 20 Kilohertz, this higher sampling rate expands the frequency response. Even for older people with more limited high frequency hearing, the improvement is evident in a smooth phase response down to lower frequencies and fewer digital artifacts (think of an artifact as the digital version of a speck of

dust on a record).

10. Budget Sonic Excellence

You don’t have to break the bank to have a big step up in audio quality. Even an inexpensive internal sound card like the Creative Sound Blaster Live! 24-bit PCI Sound Card has specs way beyond Compact Disc capability. You get the 24-bit data path for the lower noise floor and more headroom for recording. The sampling rate goes up to 96 Kilohertz, which is still a step up from the CD class.

The 96 dB dynamic range of 16-bit CD quality is fine if the program material has been carefully recorded and processed to fit. If you are doing your own recording, the additional dynamic range of 24 bits really comes in handy by allowing more headroom. You don’t want to have music peaks clip, so backing down a bit on the volume allows more space at the top. With the lower noise floor, the low volume is not a problem. Even this bargain basement sound card has the guts to give you this level of performance.

Source : http://www.geeks.com/techtips/2006/techtips-23feb06.htm