Tech Info Library

Macintosh: Sound Capabilities (9/94)

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TOPIC ----------

The following article provides information on a variety of topics relating to audio and the Macintosh.

DISCUSSION ----------

COMMON AUDIO TERMS

DIGITIZING SOUND (aka, SAMPLING)
Several thousand times per second, a number representing the current amplitude of the sound wave is recorded.

DIGITAL SOUND
Sound recorded in the above manner.

11KHZ, 22KHZ, 44KHZ SOUND
Refers to how many times per second information is recorded for a sound (11,000, 22,000, and 44,000 respectively). Most Macintosh computers can output at 22KHz, though some output at 44KHz. Audio CD's are played at 44KHz.

8-BIT, 16-BIT SOUND
Refers to the bit depth (how many different numbers are in the "sound palette" to form a sound). See separate section below about 8-bit vs. 16-bit sound.

STEREO SOUND
The ability to send DIFFERENT sound information simultaneously to both the left and right channels. Sending the same sound to two speakers is not stereo; it is dual-channel mono.

STEREO CAPABILITIES OF DIFFERENT MACINTOSH MODELS

Mac Plus, SE, Classic
8-bit mono sound to one channel (you'll hear only one side with stereo headphones, unless you use an adapter)

Performa 200, Performa 400-467 (not 47x), Classic II, LC II
Mixed 8-bit mono sound to both channels (you'll hear sound out of both sides with stereo headphones, but the sound won't be true stereo)

Performa 475, 476, LC 475, Quadra 605
Stereo 8-bit sound, including true stereo from non-audio CD's (connected externally). Audio CD's require external speakers, enhanced Apple Sound Chip supports stereo.

Performa 5xx, 63x, LC 5xx, 630, Quadra 630
Stereo 8-bit sound, including true stereo from audio and non-audio CD's (Enhanced Apple Sound Chip supports stereo).

Performa 600, 600CD except Mac IIvx
Mixed 8-bit mono sound to both channels, except true stereo from audio CD's (No ASIC to support stereo from software)

IMPORTANT NOTES:

1) Stereo is the ability to send DIFFERENT sound information simultaneously to both the left and right channels. Sending the same sound to two speakers is NOT stereo; it is dual-channel mono.
2) "Stereo sound" in the chart above means that the Macintosh SUPPORTS stereo sound, NOT that all sounds that are played are automatically stereo. Stereo sound requires that the application software generates the stereo sound for the Macintosh to play.
3) All AUDIO CD's play at 16-bit stereo, regardless of which Macintosh they're connected to. (If the CD-ROM drive is external, you'll need external speakers to hear audio CD's.)
4) For a NON-audio CD (or software on the hard drive) to play sound in either stereo or at 16-bits, two things are required:
   A- The application software must generate stereo or 16-bit sound (rare).
   B- The Macintosh it is played on must support stereo or 16-bit sound. (Recent Macintosh models support stereo; only AV, Power Macintosh, and PowerBook 500 series computers support 16-bit sound.)
5) All the Macintosh computers in the chart above can play sound sampled as high as 22KHz (except for audio CD's which play at 44KHz).

8-BIT VS. 16-BIT SOUND

8-bit or 16-bit sound refers to the "depth" of the sound (e.g., how many different possible numbers are in the "sound palette" to form a sound). Most Macintosh computers output 8-bit sound, though some support 16-bit. Audio CD's are 16-bit.

8-bit: 256 different numbers can be used to form a sound.

16-bit: 65,536 different numbers can be used to form a sound.

Software CD-ROMs could have stereo 8- or 16-bit sound files at any sampling rate (11KHz, 22KHz, 44KHz), but most of them are 8-bit mono 22KHz since that's what most Macintosh computers can play. Sound Manager 3.0 is capable of converting 16-bit audio to 8-bit audio on machines that don’t support 16-bit audio output.

Among desktop Macintosh computers, only the 660AV, 840AV, and Power Macintosh models have 16-bit audio input and output capability because of the AT&T DSP3210 hardware circuitry and the 16-bit Singer codec circuitry in the AVs. The Audio Waveform Amplifier and Converter (AWAC) chip in the Power Macintosh performs the same 16-bit I/O functionality. The PowerBook 500 series computers support 16-bit stereo output, but only mono input.

HOW AUDIO CD'S WORK ON THE MACINTOSH

All audio CD's play at 44KHz, 16-bits, and stereo, whether in a stereo system (compact disc player) or computer CD-ROM drive.

On Macintosh computers with internal CD-ROM drives, the AppleCD Audio Player program controls the CD player, and the CD player sends the sound directly to the speaker port, bypassing the logic board. This is why you can play audio CD's with no computer performance degradation, and why you get 44KHz, 16-bit, stereo output, even if your Macintosh can't play sounds from software with that quality.

For Macintosh computers with external CD-ROM drives, external speakers are required to hear audio CD's. This is because the sound from audio CD's is not sent to the computer through the SCSI cable as data, but rather the sound is sent directly to the speaker output port of the CD-ROM drive.

SOUND QUALITY & SIGNAL-TO-ERROR RATIO

In digital audio, the main measurement of maximum expressible amplitude to error ratio is called Signal-to-Error (S/E) ratio. This expressible amplitude is also referred to as the "maximum signal" of the recorded sound. The error is what is perceived as noise. The S/E ratio specification of a digital system is closely related to the Signal-to-Noise (S/N) ratio of an analog system, although it is not identical in nature due to differences between digital and analog methods.

The S/E ratio can be expressed specifically by calculating first a maximum signal value, second an error value, and finally creating their ratio. Although there are intervening steps in the math, the final formula to use when calculating the strength of the audio signal above the noise (distortion or error) level looks like this:

$$6.02 * n + 1.76 \text{ dB}$$

Where n is equal to the number of bits in the sample. The following results are

approximate signal above noise ratios for a various number of bits in a sample. Generally, the calculated results will be slightly
higher than the measured results. Also, specific implementations of hardware will affect the actual measured ratios in a downward fashion.

16-bit samples (number in audio CDs)	= 98 dB
12-bit samples	= 86 dB
8-bit samples (most Macintosh sound)	= 48 dB

To relate the quality of these digital recordings to analog recordings, think of the 8-bit recordings as inexpensive cassette recorders with inexpensive tape. The 12-bit recordings correlate to high quality cassette recorders with noise reduction and metal tape. The 16-bit recordings equate to professional studio reel-to-reel tape recorders with noise reduction and professional tape at high tape speeds.

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