Subject: Re: Why SE in SET amps?
Posted by Thermionic on Wed, 26 May 2010 06:00:04 GMT
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Pano wrote on Sun, 23 May 2010 17:54But what about amps with 0.0001% THD? Shouldn't they be better? By that number, they should be. But that does not tell us what the harmonic structure is. And the ear is very good at hearing those harmonics, even if they are tiny. Also, those amazing numbers are usually taken only at 1Khz and a fixed level. That is far form the whole story. The harmonic structure determines the sound of the amp.

Indeed! So true! THD tells you absolutely nothing about how the amplifier will sound. On that note, below is an excerpt from a white paper I wrote on THD and IMD a few years back, that I'd like to share. I apologize that much of it has already been covered in this thread, but I had to include it so that what hasn't been covered will make sense.

"Besides the psychoacoustic effects of different orders of harmonic distortions, perhaps even fewer people understand how "on-paper" distortion percentages correlate to the ear's actual perception of them. If you test an amplifier on a harmonic distortion analyzer, and it tells you there is 1% THD, does that mean there's really 1% THD? The answer is yes, and no. The analyzer measures the distortion as a voltage that represents a percentage of the main signal voltage, not its actual sonic perception. Or, as I like to put it, "Test equipment ain't got ears. People do." However, some simple math can provide a relative conversion from volts to perceived sound pressure level.

The HD analyzer tells us that we have 1% THD, which is about 40dB below the fundamental. Converting -40dB to wattage would be 1/10,000 of the full power, which with a 10 watt amp cranked to the point of clipping would be 1 milliwatt worth of distortion. Now, here's where we get down to the nitty gritty.....

These wattage/percentage figures do not tell us how they will be perceived by actual human ears, because the ear does not perceive volume in a linear manner, but on a logarithmic curve. To net a doubling of perceived volume (approximately equal to 10dB) requires 10 times the power; likewise a halving of the perceived volume requires cutting the power by 10 times. So, -40dB roughly represents an actual 16:1 ratio to the ear's perception, not a 10,000:1 ratio as indicated by the voltage percentage, because the ear hears -10dB as one-half the volume, -20 one-fourth the volume, -30dB one-eighth the volume, and -40dB as one-sixteenth the volume.

OK, now let's see what 1% measured THD really sounds like to real human ears.

100% ÷ 16 = 6.25%

This illustrates how the ear can very easily pick out tiny percentages of high order harmonics. Consider a nasty high order harmonic that's buried -80dB down. To the ear, a 7th harmonic at -80dB sounds like 3.1% 7th order distortion, very offensive indeed! Add all the other harmonics from 3rd through 6th with it, and you've got yourself a real mess! Then, consider that when listening to music you're not dealing with a single frequency as in an industry-standard THD test, but a very complex arrangement composed of a nearly infinite number of simultaneous frequencies. Once again, psychoacoustic effects carry far more weight than measured specifications on paper!

Finally, as if things weren't already bad enough, we have a lot more than harmonic distortions to contend with. We have non-harmonic intermodulation distortions too! Any time you put two frequencies together you create two new ones, which are the sum of the two and the difference between them. These are, not surprisingly, called the quadratic sum and difference frequencies. Most of the time, the resulting intermodulations are musically unrelated to the original frequencies and therefore horribly dissonant.

Let's use a 440Hz sinewave as an example, which is the tuning standard for musical instruments. It is the open A string of the guitar, the A note above middle C on the piano, and two octaves below the open A string of the violin.

If we add an 880Hz sinewave with it (which is an A note exactly one octave higher), we'll have the original 440Hz and 880Hz frequencies, plus the sum frequency of 1.32kHz and the difference frequency of 440Hz. 1.32kHz is an E note, which is a musical fifth above the 880Hz A note and equivalent to the 3rd harmonic of the 440Hz A note. Not too terribly dissonant sounding, by any means.

Interestingly, if we superimpose that 1.32kHz E note sinewave over the 440Hz A note, we'll get:

Sum: 440Hz + 1.32kHz = 1.76kHz
Difference: 1.32kHz - 440Hz = 880Hz

Notice that 1.76kHz is exactly one octave above 880Hz, or two octaves above our original A-440 note. Therefore, we still have A notes and an E note! This illustrates how low order harmonically-related tones intermodulate to form harmonically related tones of similar nature.

Now, let's move on to a higher order, yet still harmonically related tone, intermodulate it with our A-440 note, and see what comes out. Let's use a musical third, that's in the third octave above the fundamental. This would be a C# note, which would correlate to a 5th order harmonic relative to the A-440 fundamental.

Sum: 440Hz + 2.217kHz = 2.657kHz
Difference: 2.217kHz - 440Hz = 1.777kHz

The resulting intermodulation frequencies are musically unrelated to both the original fundamental tones. The sum frequency falls between a musical E and F in pitch, and therefore that frequency will be dissonant regardless of what the original fundamentals were. The difference frequency is 17Hz sharper than the nearest actual note (an A note), so that it would sound something like two musicians playing the same piece together but with their instruments badly out of tune with each other, which makes for a rather hair-raising discordance.

From these simple examples, you can see two things become very clear when we relate this concept to harmonic and inharmonic distortions in amplifiers. One, the more frequencies that are simultaneously present in the music, the more intermodulation distortions you'll have. Two, high order harmonic distortions give way to some very dissonant intermodulations. These IM distortions are a chief reason why many amplifiers are harsh and fatiguing to listen to, and sound homogenized and congested when playing complex passages."

Thermionic
