

IMPLICATIONS OF NONLINEAR DISTORTION IN THE ULTRASONIC CAPACITIVE MICROPHONE

Why is the wide-bandwidth condenser microphone a bad idea?

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ABSTRACT

This paper introduces an argument against ultrasonic bandwidth in the condenser microphone.

The known potential for ultrasonic content in acoustic musical instruments, combined with the known relationship of rising nonlinear distortion with rising frequency in the capacitive microphone is considered.

1. INTRODUCTION

In recent times, small diaphragm condenser microphones with ultrasonic bandwidth have been marketed to & become popular in the professional audio community.

Arguments that such extended bandwidth is necessary are often qualified with the position that since musical instruments have been shown to produce significant acoustic output at ultrasonic frequencies [1], it is necessary to record this range in order to reproduce the audible spectrum cleanly.

Generally, the question of whether this ultrasonic component is audible tends to dominate & misdirect

discussion and little thought is given to the indirect consequences of transducers reaching this bandwidth.

2. ULTRASONIC BANDWIDTH

The question of how ultrasonic bandwidth is achieved is integral to the question of why it should not be.

Since bandwidth is directly related to diaphragm scale & mass, very small diaphragms are necessary to provide extension of frequency response into the ultrasonic range.

However, the use of a very small diaphragm causes a decrease in output, which increases self noise-level.

Often, this question of decreased output is addressed by increasing proximity of the diaphragm to the back-plate.

This increase in proximity achieves an increase in sensitivity, which reduces noise-floor to acceptable levels.

However, as nonlinear distortion in the capacitive microphone is directly & proportionally related to back plate proximity [2], any increase in proximity here represents a proportional increase in nonlinear distortion.

The same is true of any reduction in diaphragm mass, where the resulting increased sensitivity simply increases nonlinear distortion proportionally.

For this reason, the wide-bandwidth small diaphragm condenser microphone represents a fundamental compromise between noise performance and linearity, where the designer must decide whether noise performance or linearity is the priority.

Commonly, as in cases where noise performance is critical, linearity is necessarily compromised by increased back-plate proximity.

While this increase of nonlinear distortion in the audible band represents a significant issue in & of itself, it is the nature of rising nonlinear distortion with frequency that is of greatest concern in the ultrasonic application.

3. RISING NONLINEAR DISTORTION WITH FREQUENCY

It is well known that the capacitive microphone shows rising nonlinear distortion with frequency.

Typically, in the best case scenario (symmetrical capsule design), this approximately entails a doubling of nonlinear distortion for every doubling of frequency [3].

Where we see microphones with flat mechanical frequency response to 50kHz or even 100kHz, it is very

important to look at the nonlinear distortion performance at these frequencies, not least as the rising trends shown in the audible band can reasonably be expected to continue through the ultrasonic band to extremely high levels of distortion.

4. ULTRASONIC MUSICAL OUTPUT

Perhaps the most popular argument for the ultrasonic microphone concerns the fact that there is significant ultrasonic acoustic energy known to be produced in many musical instruments [1].

However, for the purposes of this discussion it is proposed that this ultrasonic content is, by definition, to be considered inaudible.

Given that the capacitive microphone is known to show steeply rising nonlinear distortion with frequency, it is critical to consider the resulting interaction between the very high nonlinear distortion at ultrasonic frequencies and the relatively high acoustic energy at those frequencies.

In fact, though in cases of ultrasonic musical content we generally see a trend of falling energy with frequency [1], this falling energy is more or less counteracted by the corresponding rising level of nonlinear distortion [3] in the microphone.

In light of this, while associated harmonic distortion will remain in the ultrasonic band, we can reasonably expect nonlinear distortion difference (intermodulation) products in the audible band at significant levels.

5. CONCLUSIONS

Essentially, this discussion forms a basis for the argument that the low-bandwidth microphones of the past actually show a significant & measurable advantage over the modern wide-bandwidth condenser microphone, in the question of audible-band non-harmonic products of ultrasonic intermodulation distortion.

That we can relate directly the term ‘musicality’ to the presence or absence of non-harmonic components in the audible band, allows us to relate bandwidth itself directly to musicality in this case.

Perhaps, this perspective will finally allow a large part of the professional audio industry to be vindicated in their long held observation that the old microphones are more musical than the modern measurement derived designs – *though not for the commonly held reasons of ‘euphonic distortion’ but for the significant absence of ultrasonic related non-harmonic distortion products.*

Certainly, the mechanical limitations (high frequency roll-off) of these old microphones constitutes a measurable advantage over the modern wide-bandwidth designs, since the absence of sensitivity at ultrasonic frequencies dictates that there can be no intermodulation products of ultrasonic energy.

Finally, it must be concluded that the extremely high nonlinear distortion levels predicted at ultrasonic frequencies in wide-bandwidth capacitive microphones argues convincingly that this wide-bandwidth transducer is a bad idea as it can only lead to increased non-harmonic distortion in the audible band.

REFERENCES

- [1] Boyk, James, "There's Life Above 20 KiloHertz! A Survey of Musical Instrument Spectra to 102.4 KHz", <http://www.cco.caltech.edu/~boyk/spectra/spectra.htm>, May 2000
- [2] Hibbing, Manfred; Griese, Hans-Joachim, "New Investigations on Linearity Problems of Capacitive Transducers", AES Convention: 68, Paper number: 1752, March 1981
- [3] Willett, John, "THE SYMMETRICAL MICROPHONE CAPSULE AND THE QUEST FOR THE PERFECT "ACOUSTIC WINDOW"". AES UK 13th Conference: "Microphones & Loudspeakers" , Paper Number: MAL-02, March 1998.