Digital encoding requirements for high dynamic range microphones

About this document

Scope and purpose

This application note describes the relationship between microphone dynamic range, audio channel dynamic range, and overall system performance. It explains the importance of using a 20 bit or 24 bit encoding system with high dynamic range MEMS microphones.

Intended audience

Infineon XENSIV^{TM} high dynamic range MEMS microphone customers.

Table of contents

About this document 1

1 Microphone dynamic range 2

2 Audio channel dynamic range 2

3 Effects of limited dynamic range in high performance microphone systems 4

Disclaimer 5

1 Microphone dynamic range

Two main parameters of a microphone are Signal to Noise Ratio (SNR) and Acoustic Overload Point (AOP).

These parameters reflect:

- The quietest sound a microphone can detect (SNR)
- The loudest sound a microphone can detect (AOP)

By combining these two parameters we can determine the entire range of sound levels which a microphone can detect, from the noise floor to the overload point.

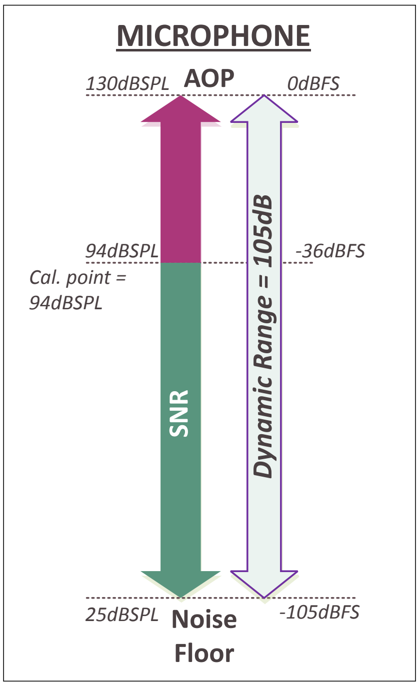

Figure 1 Example dynamic range of IM69D130 microphone.

2 Audio channel dynamic range

Audio system components such as ADCs and CODECs also have specifications for Dynamic Range and SNR. These specifications are measured in a significantly different way to a microphone SNR.

Microphone SNR is defined as the difference (in dB[A]) between the microphone output when the acoustic input is a 1kHz sine wave at 94dBSPL and when there is no acoustic input to the microphone (noise floor). This is because microphone SNR is a measurement of the audibility of the microphone self noise, so it is referred to a defined acoustic “real world” signal.

ADC / CODEC SNR is generally defined as the difference (in dB) between the maximum possible input signal level and the minimum possible input signal level. This performance is usually reflected in the bit depth of the digital encoding scheme used, typically 16 bit, 20 bit or 24 bit. This means that the audio components’ SNR is actually more closely related to the microphone Dynamic Range than microphone SNR.

It is necessary to select audio components and a digital encoding scheme which have equivalent or greater SNR/ Dynamic Range than the Dynamic Range of the microphone being used. If not, the noise floor of these audio components will dominate the system and the full microphone performance will not be realised.

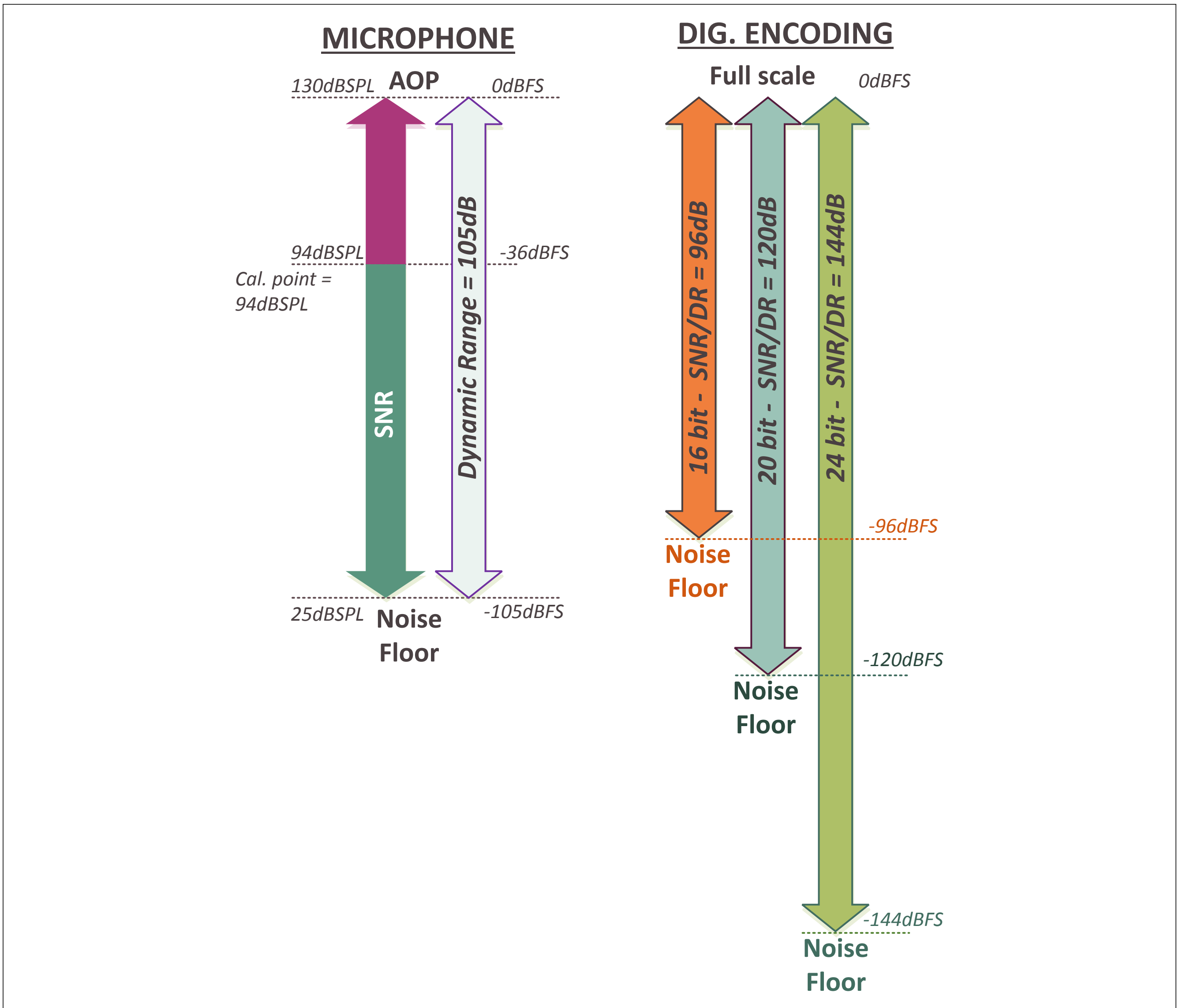

Figure 2 **16 bit encoding clearly does not have sufficient Dynamic Range for this microphone. The system performance will be limited by the audio encoding scheme. In this case a 20-bit or 24-bit audio signal chain should be used to allow the full microphone performance.**

3 Effects of limited dynamic range in high performance microphone systems

The dynamic range of a digital encoding scheme can be calculated easily:

- DR[dB] = 1.76 + (N*6.02)
- (N = number of bits)

For easy estimation this can be reduced to:

- DR[dB] = N*6

All digital signals are measured in dBFS: dB relative to full scale.

Full scale is the maximum number which can be represented in the digital numbering system. In PDM, this is represented by 100% 1's in the output. In a digital MEMS microphone, the AOP is represented by 0dBFS (full scale). All other output levels are specified as –xdBFS, signifying that they are lower than full scale.

The Dynamic Range of the CODEC or ADC specifies the lowest number which can be represented by its digital encoding scheme. The full scale levels of the microphone and downstream components will generally align regardless of the signal chain dynamic range. However the noise floors may not. This is because 0dBFS (full scale) is the same for both systems, but the digital numbering system used by the audio signal chain may not be able to represent levels as low as the microphone noise floor. This means that if a digital microphone is used with a digital encoding scheme which does not use enough bits to represent the noise floor of the microphone, the system noise will not reflect the microphone's true performance.

If a high SNR microphone is to be used in an audio signal chain using low dynamic range (16 bits), the microphone can be calibrated to have a reduced AOP. Reducing the microphone dynamic range by reducing the AOP level will preserve the microphone's SNR performance, even in a low dynamic range signal chain.

If high AOP AND high SNR are required, a 20 bit or 24 bit audio signal chain must be used.

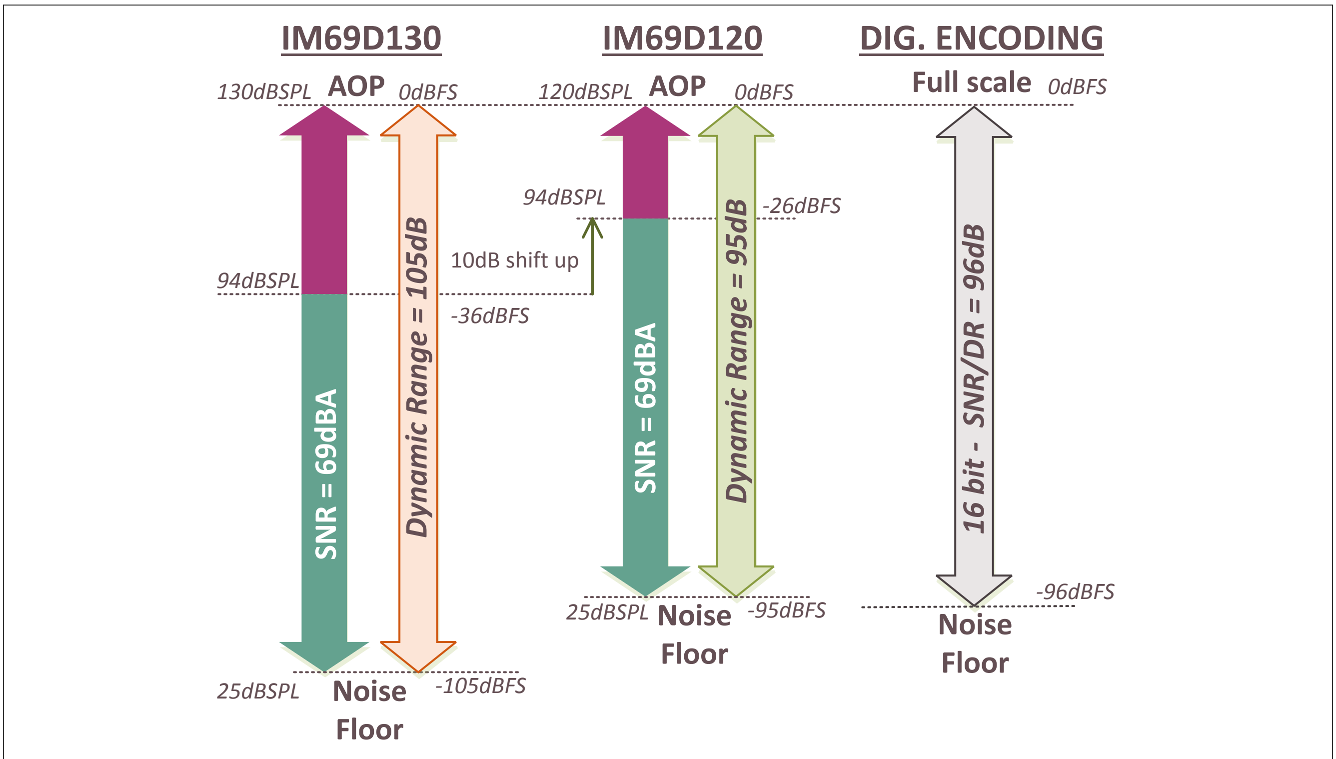

Figure 3 In this case the IM69D120 can be a better choice than the IM69D130. Reducing the AOP by 10dB means the Dynamic Range is reduced to 95dB, and fits with a 16 bit audio signal chain

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