SPH0645LM4H ALIASING PERFORMANCE

knowles

Sampling an analog signal will introduce aliasing. How much aliasing is included in the audio samples is controlled by downstream filtering. This document describes the performance of the sigma-delta modulator and decimation filtering in the SPH0645LM4H (Crawford) Digitial I2S Microphone.

SIGNAL BANDWIDTH AND CLOCK

The SPH0645LM4H (Crawford) microphone consists of a high-performance SiSonic™ acoustic sensor, a sigma-delta Analog to Digital convertor, decimation filtering, and an interface to condition the signal into an industry standard 24-bit I2S format.

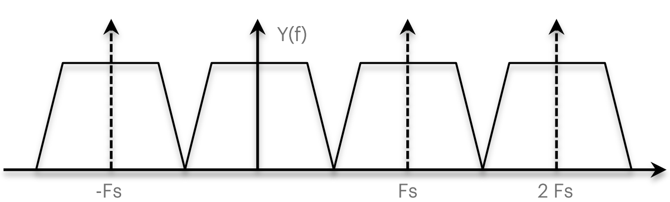
For the decimation, the oversampling rate is fixed at 64. This implies that the sampling rate, Fs, is Fclock/64 and maximum input frequency of the audio signal, the signal bandwidth) should be less than Fclock/128 (BW < Fs/2). The table below shows the sample rate and Nyquist frequency for various clock rates supplied to the SPH0645LM4H microphone.

Table 1: Sampling Rate and Bandwidth as a function of Clock Rate

Clock Rate (Fclock)	Audio Sample Rate (Fs)	Maximum Audio Bandwidth (Fs/2)
1.024MHz	16 kHz	8 kHz
2.048MHz	32 kHz	16 kHz
3.072MHz	48 kHz	24 kHz
4.096MHz	64 kHz	32 kHz

ALIASING OF HIGH-FREQUENCY SIGNALS

Sampling theory tell us that the spectrum of the sampled audio will be replicated about all multiples of the sampling rate as shown below.



Audio above the Nyquist Fs/2 will similarly be replicated in the baseband audio. This is aliasing.

The PDM output of a sigma-delta modulator needs to be low-pass filtered and decimated to produce audio samples at the sampling rate. Once the audio has been decimated or downsampled, it is no longer feasible to filter out signals above Fs/2.

The SPH0645LM4H microphone performs this decimation. The sections of this document that follow will show performance of this filtering in the presence of audio exceeding the Nyquist frequency.

Four (4) sampling rates generated by use of four different clocks show the relationship between Fs and the audio output for the SPH0645LM4H microphone. A 22kHz tone at 94 dB SPL is provided at the input of the microphone.

1.024MHZ CLOCK

The 22kHz input tone will alias to NxFs ± 6kHz as the tone is 6kHz above the sample rate of 16kHz. The theoretical aliased tones and lab measurements are shown here for the SPH0645LM4H microphone.

Figure 1. 22kHz tone and aliases for Fclock=1.024MHz, Fs=16kHz

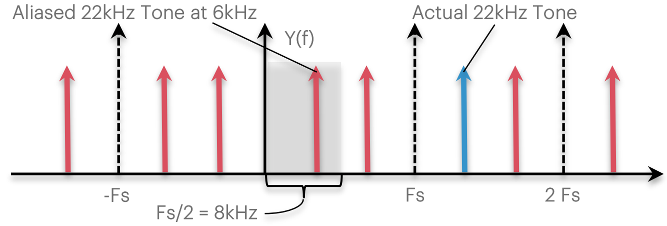
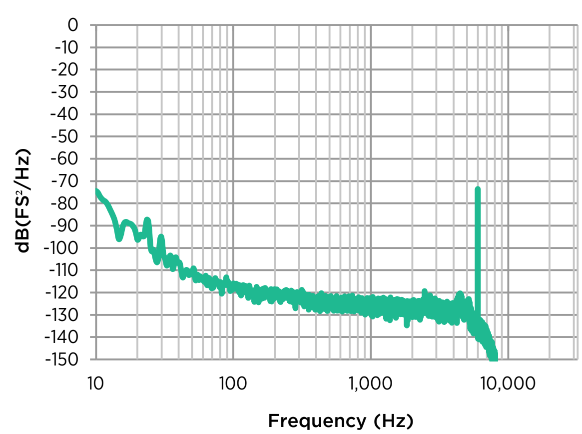


Figure 2. PSD for Fclock = 1.024MHz in the presence of a 22kHz, 94 dB SPL tone



2.048MHZ CLOCK

The 22kHz input tone will alias to NxFs ± 6kHz as the tone is 6kHz above the sample rate of 16kHz. The theoretical aliased tones and lab measurements are shown here for the SPH0645LM4H microphone.

Figure 3. 22kHz tone and aliases for Fclock=2.048MHz, Fs=32kHz

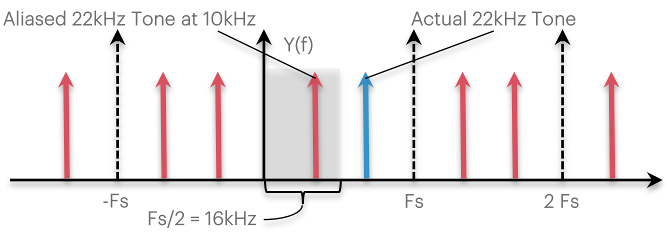
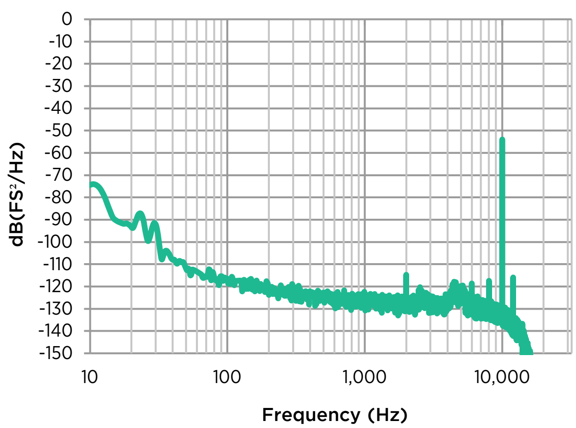


Figure 4. PSD for Fclock=2.048MHz in the presence of a 22kHz, 94 dB SPL tone



3.072MHZ CLOCK

The 22kHz input tone will alias to NxFs ± 22kHz as the tone is within the Nyquist rate—24kHz for a 48kHz samping rate. The theoretical aliased tones and lab measurements are shown here for the SPH0645LM4H microphone.

Figure 5. 22kHz tone and aliases for Fclock=3.072MHz, Fs=48kHz

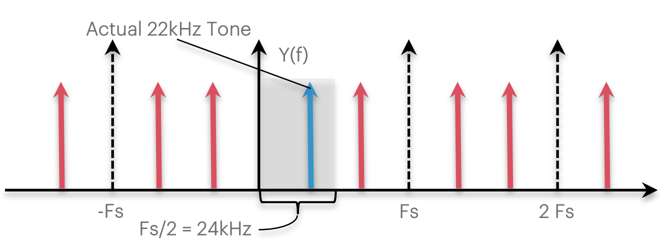
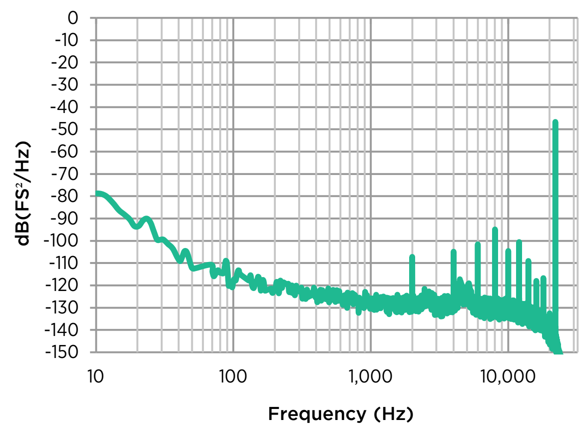


Figure 6. PSD for Fclock=3.072MHz in the presence of a 22kHz, 94 dB SPL tone



4.096MHZ CLOCK

The 22kHz input tone will alias to NxFs ± 22kHz as the tone is within the Nyquist rate—32kHz for a 64kHz samping rate. The theoretical aliased tones and lab measurements are shown here for the SPH0645LM4H microphone.

Figure 7. 22kHz tone and aliases for Fclock=4.096MHz, Fs=64kHz

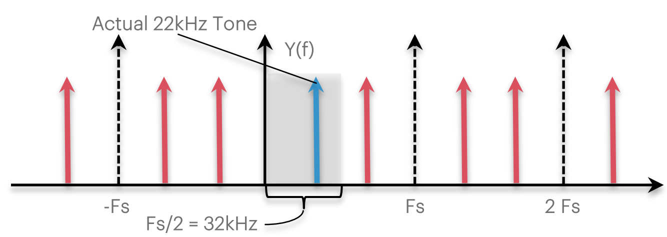
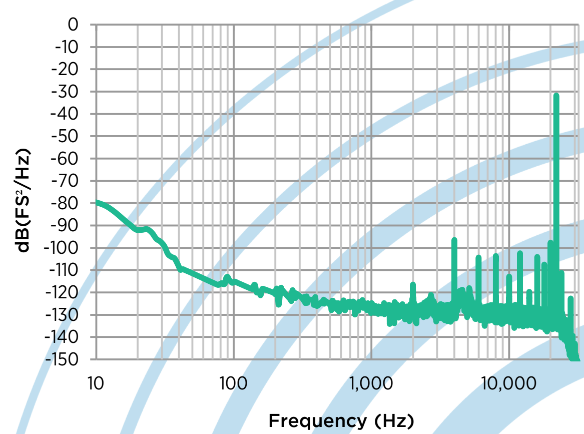


Figure 8. PSD for Fclock=4.096MHz in the presence of a 22kHz, 94 dB SPL tone.



Knowles Corporation
1151 Maplewood Drive
Itasca, Illinois 60143

Phone: 1 (630) 250-5100
Fax: 1 (630) 250-0575
sales@knowles.com

Model/Reference Number:
SPH0645LM4H APPLICATION NOTE