
Configuring the WM7216 & WM7236 Always-On Microphones

INTRODUCTION

The WM7216 and WM7236 are a matched pair of top and bottom port, low-profile digital silicon MEMS microphones, optimised for use with low-power applications running Cirrus Logic always-on voice control software, 'SoundClear Capture'. This applications note explains:

- How to configure the WM7216/WM7236 for different modes of operation
- How to optimise the clock frequency when integrating with an audio codec
- Detail on the performance advantages of 'Hi-Fi Record' and 'Voice' modes

MODES OF OPERATION

The WM7216 and WM7236 microphones support three modes of operation, selected according to the applied clock frequency.

'Hi-Fi Record' mode offers best audio experience with wide dynamic range and class-leading THD performance. It provides low noise floor performance and supports bandwidths into the ultrasonic region.

'Voice' mode offers low current consumption, whilst maintaining class-leading THD and retains excellent SNR performance to meet the requirements of speech recognition algorithms and high quality voice calls.

'Sleep' mode puts the microphone into an extremely low power state (consuming <math><10\mu\text{A}</math>). This allows the microphone to be shut down during idle periods and re-enabled very quickly by applying DMICCLK.

The different modes of operation can be selected according to Table 1 below:

MODE	DMICCLK RANGE	DMICCLK TYPICAL
Hi-Fi Record Mode	2.4MHz to 4.9MHz	3.072MHz
Voice Mode	300kHz to 800kHz	768kHz
Sleep Mode	0Hz	0Hz

Table 1 Modes of operation and the associated DMICCLK frequencies

CLOCK FREQUENCY SELECTION

When connecting the WM7216 or WM7236 microphones to a digital system there are a number of considerations besides the DMICCLK frequency that need to be made to ensure optimal performance in each mode.

The first consideration is the signal bandwidth. In 'Hi-Fi Record' mode, optimal performance is obtained with a signal bandwidth of up to 48kHz. In 'Voice' mode, optimum performance is obtained with a signal bandwidth of up to 8kHz. Beyond these bandwidths, quantisation noise occurs due to the sigma-delta modulator within the ADC internal to the microphone. This leads to noise shaping at the microphone output, where the noise level increases for frequencies above the optimal frequency range.

Figure 1 shows the microphone output noise in 'Voice' mode, with a DMICCLK of 768kHz. The increased noise level above 8kHz can be clearly observed.

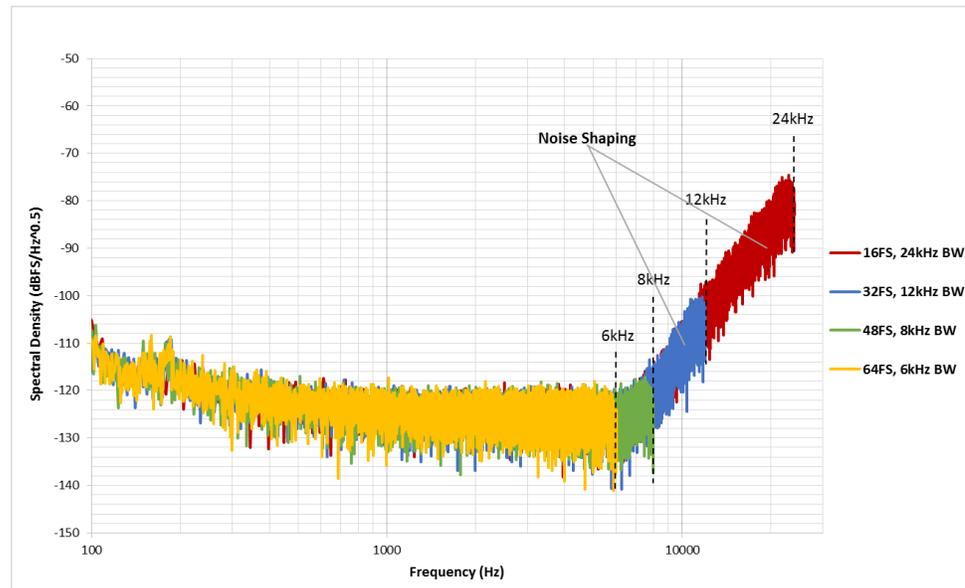


Figure 1 Noise Spectrum at different decimation ratios at DMICCLK = 768kHz

To avoid noise shaping for a given signal bandwidth, the system in which the microphones are connected to needs to be considered, where the sample rate configuration and decimation ratio of the system is aligned to the signal bandwidth.

When used with one of Cirrus Logic's audio codecs such as the WM8281, the microphone signal path sample rate can be selected to be between 8kHz to 192kHz, using the SAMPLE_RATE_x register and the DMICCLK frequency set by the IN_x_OSR register.

The signal bandwidth can be calculated as:

$$\text{Bandwidth} = \frac{\text{Sample Rate}}{2}$$

The decimation ratio can be calculated as:

$$\text{Decimation Ratio} = \frac{\text{DMICCLK frequency}}{\text{Sample Rate}}$$

It should be noted that the ADC internal to the microphone is designed to operate optimally with a decimation ratio of 48 to 50. If a higher ratio is used, such as 64, proportionally less signal bandwidth will be obtained. If a lower ratio is used, such as 32, more of the sigma-delta modulator noise will be present as shown in Figure 1.

Table 2 below shows some examples of valid configurations for different decimation ratios and microphone DMICCLK frequencies. The highlighted rows are the most optimal:

DMICCLK	SAMPLE RATE	SIGNAL BANDWIDTH	DECIMATION RATIO
512kHz	16kHz	8kHz	32
768kHz	24kHz	12kHz	32
3.072MHz	96kHz	48kHz	32
4.608MHz	144kHz	72kHz	32
768kHz	16kHz	8kHz	48
3.072MHz	64kHz	32kHz	48
4.608MHz	96kHz	48kHz	48
800kHz	16kHz	8kHz	50
2.4MHz	48kHz	24kHz	50
4.8MHz	96kHz	48kHz	50
768kHz	12kHz	6kHz	64
3.072MHz	48kHz	24kHz	64
4.608MHz	72kHz	36kHz	64
3.072MHz	24kHz	12kHz	128
4.608MHz	36kHz	18kHz	128

Table 2 Example Signal Bandwidth and Decimation Ratio configurations

PERFORMANCE IN 'HI-FI RECORD' AND 'VOICE' MODES

'Hi-Fi Record' mode and 'Voice' mode both offer distinct advantages, and their selection depends on the required microphone use-case and application. Table 3 shows a summary of the key performance parameters offered by the two modes of operation:

MODE	THD (1%)	SNR	TYPICAL CURRENT CONSUMPTION	DYNAMIC RANGE	TYPICAL SIGNAL BANDWIDTH
Voice Mode (DMICCLK = 768kHz)	118dB SPL	60dB	280µA	84dB	200Hz to 8kHz
Hi-Fi Record Mode (DMICCLK = 3.072MHz)	118dB SPL	63dB	980µA	87dB	20Hz to 22kHz

Table 3 Key Performance Parameters in 'Voice' and 'Hi-Fi Record' modes

It can be seen that 'Hi-Fi Record' mode offers better Signal to Noise ratio (SNR), whilst 'Voice' mode offers lower current consumption. However, both modes offer wide dynamic range performance, corresponding to high quality recording capability for loud or quiet audio signal sources.

NOISE PERFORMANCE

The WM7216 and WM7236 microphones provide 60dB Signal to Noise Ratio (SNR) in the 'Voice' mode and 63dB SNR in the 'Hi-Fi Record' mode. This means that, in both modes, the microphones meet the 60dB SNR specification typically required for high quality voice calls and always-on voice control algorithms. Additionally, system designers can take full advantage of the low current consumption offered by 'Voice' mode.

Figure 2 provides further detail of the noise floor for different clock frequencies, where it can also be seen that increasing clock frequency provides improvements in bandwidth. For applications to take most advantage of these improvements the microphone should be configured in 'Hi-Fi Record' mode.

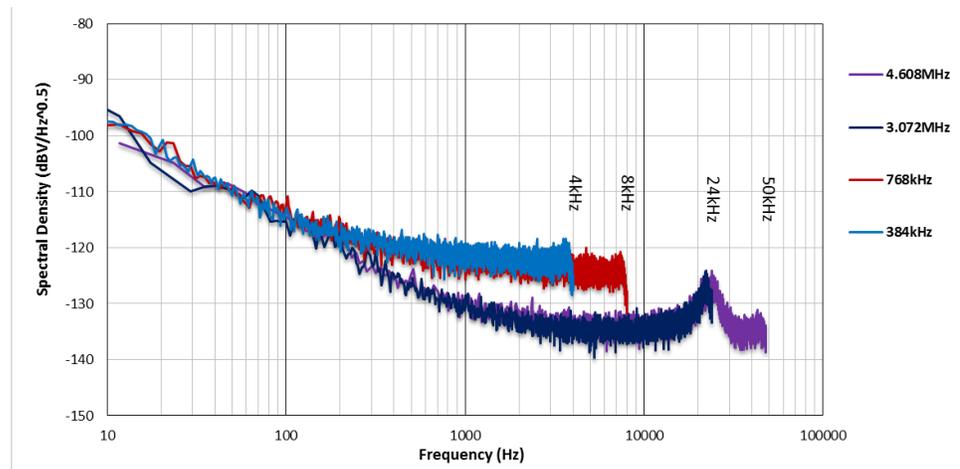


Figure 2 Noise Spectrum at different DMICCLK frequencies

CURRENT CONSUMPTION

The key benefit of 'Voice' mode is a significant reduction in current consumption, in return for lower signal bandwidths.

This can be seen in Figure 3, which shows the current consumption (without load) at different DMICCLK frequencies alongside the corresponding signal bandwidth for that clock frequency.

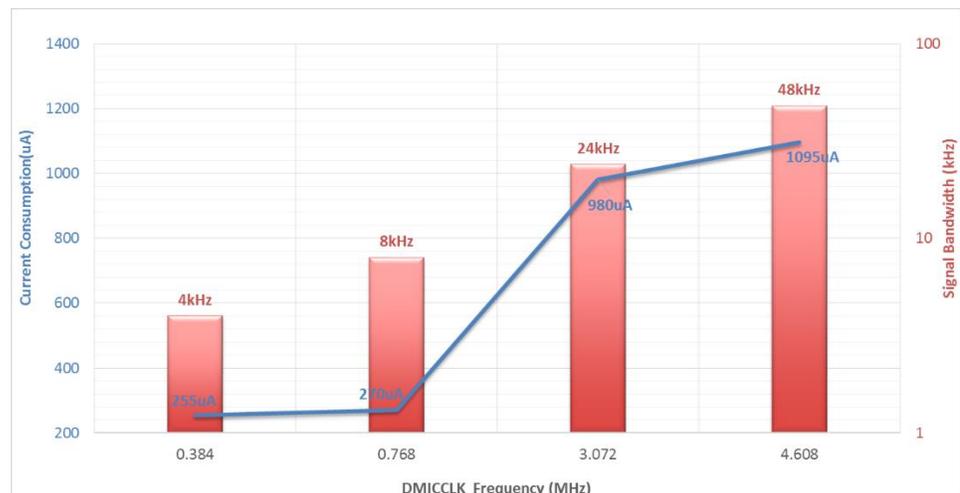


Figure 3 Current Consumption and Signal Bandwidth at different DMICCLK frequencies

THD PERFORMANCE

The WM7216 and WM7236 offer excellent Total Harmonic Distortion (THD) performance; the 1% THD specification is maintained in 'Hi-Fi Record' mode and 'Voice' mode, which ensures high quality audio, irrespective of the operating mode. This can be seen in Figure 4 below, which shows a plot of THD against Sound Pressure Level at different DMICCLK frequencies.

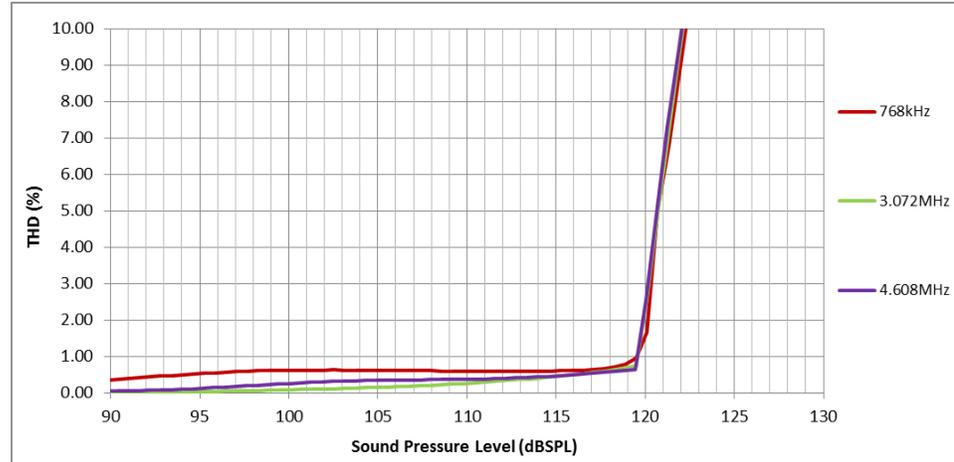


Figure 4 WM7236/WM7216 THD vs Amplitude at different DMICCLK frequencies

The importance of the 1% THD parameter is that this is generally accepted as the onset of audible distortion products. As indicated in Figure 4, the WM7216 and WM7236 microphones offer less than 1% THD below 118dB SPL, in both 'Voice' and 'Hi-Fi Record' modes. Below 118dB SPL, the low distortion levels maintain crisp, high quality recording in both modes.

As discussed previously, the WM7216 and WM7236 microphones can be operated in 'Hi-Fi Record' mode for applications which require wide dynamic range, very high SNR and performance across the full audio band (20Hz to 20kHz). These applications include high-definition audio or video recording. Moreover, the operating bandwidth can be extended into the ultrasonic band (20kHz to 48kHz), to enable ultrasonic applications such as gesture control etc.

The microphones can be operated in 'Voice' mode when operation in the voice band is required (up to 8kHz) or if low power operation is required. These applications include high quality voice calls, and advanced applications running Cirrus Logic always-on voice control software, 'SoundClear Capture'.

CONCLUSIONS

The WM7216 and WM7236 microphones can be configured for optimal performance in a wide range of applications by controlling by the DMICCLK frequency to enable different modes of operation.

These modes of operation can be optimised further when connecting to a digital system by configuring the system's decimation ratio, sample rate and digital microphone clock frequency appropriately. This enables optimum performance and full bandwidth of the signal for different use cases.

'Hi-Fi Record' mode offers excellent SNR, wide dynamic range and operation in both audio (20Hz to 20kHz) and ultrasonic bands (20kHz to 48kHz). 'Voice' mode offers significant reduction in current consumption while meeting key specifications for high quality voice and operation in the voice band up to 8kHz.

The microphones are therefore ideal for 'Always-On' voice trigger applications where the flexibility of operation and high performance of key parameters place these microphones in a unique place in the market.

Contacting Cirrus Logic Support

For all product questions and inquiries, contact a Cirrus Logic Sales Representative.

To find one nearest you, go to www.cirrus.com.

The products and services of Cirrus Logic International (UK) Limited; Cirrus Logic, Inc.; and other companies in the Cirrus Logic group (collectively either "Cirrus Logic" or "Cirrus") are sold subject to Cirrus Logic's terms and conditions of sale supplied at the time of order acknowledgment, including those pertaining to warranty, indemnification, and limitation of liability. Software is provided pursuant to applicable license terms. Cirrus Logic reserves the right to make changes to its products and specifications or to discontinue any product or service without notice. Customers should therefore obtain the latest version of relevant information from Cirrus Logic to verify that the information is current and complete. Testing and other quality control techniques are utilized to the extent Cirrus Logic deems necessary. Specific testing of all parameters of each device is not necessarily performed. In order to minimize risks associated with customer applications, the customer must use adequate design and operating safeguards to minimize inherent or procedural hazards. Cirrus Logic is not liable for applications assistance or customer product design. The customer is solely responsible for its selection and use of Cirrus Logic products. Use of Cirrus Logic products may entail a choice between many different modes of operation, some or all of which may require action by the user, and some or all of which may be optional. Nothing in these materials should be interpreted as instructions or suggestions to choose one mode over another. Likewise, description of a single mode should not be interpreted as a suggestion that other modes should not be used or that they would not be suitable for operation. Features and operations described herein are for illustrative purposes only.

CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE ("CRITICAL APPLICATIONS"). CIRRUS LOGIC PRODUCTS ARE NOT DESIGNED, AUTHORIZED OR WARRANTED FOR USE IN PRODUCTS SURGICALLY IMPLANTED INTO THE BODY, AUTOMOTIVE SAFETY OR SECURITY DEVICES, NUCLEAR SYSTEMS, LIFE SUPPORT PRODUCTS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF CIRRUS LOGIC PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER'S RISK AND CIRRUS LOGIC DISCLAIMS AND MAKES NO WARRANTY, EXPRESS, STATUTORY OR IMPLIED, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE, WITH REGARD TO ANY CIRRUS LOGIC PRODUCT THAT IS USED IN SUCH A MANNER. IF THE CUSTOMER OR CUSTOMER'S CUSTOMER USES OR PERMITS THE USE OF CIRRUS LOGIC PRODUCTS IN CRITICAL APPLICATIONS, CUSTOMER AGREES, BY SUCH USE, TO FULLY INDEMNIFY CIRRUS LOGIC, ITS OFFICERS, DIRECTORS, EMPLOYEES, DISTRIBUTORS AND OTHER AGENTS FROM ANY AND ALL LIABILITY, INCLUDING ATTORNEYS' FEES AND COSTS, THAT MAY RESULT FROM OR ARISE IN CONNECTION WITH THESE USES.

This document is the property of Cirrus Logic and by furnishing this information, Cirrus Logic grants no license, express or implied, under any patents, mask work rights, copyrights, trademarks, trade secrets or other intellectual property rights. Any provision or publication of any third party's products or services does not constitute Cirrus Logic's approval, license, warranty or endorsement thereof. Cirrus Logic gives consent for copies to be made of the information contained herein only for use within your organization with respect to Cirrus Logic integrated circuits or other products of Cirrus Logic, and only if the reproduction is without alteration and is accompanied by all associated copyright, proprietary and other notices and conditions (including this notice). This consent does not extend to other copying such as copying for general distribution, advertising or promotional purposes, or for creating any work for resale. This document and its information is provided "AS IS" without warranty of any kind (express or implied). All statutory warranties and conditions are excluded to the fullest extent possible. No responsibility is assumed by Cirrus Logic for the use of information herein, including use of this information as the basis for manufacture or sale of any items, or for infringement of patents or other rights of third parties. Cirrus Logic, Cirrus, the Cirrus Logic logo design, and SoundClear are among the trademarks of Cirrus Logic. Other brand and product names may be trademarks or service marks of their respective owners.

Copyright © 2014–2015 Cirrus Logic, Inc. All rights reserved.