

## Suggested ALC Settings for Portable Devices

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### INTRODUCTION

This document applies to all WM Codec devices for portable applications. There are currently 3 versions of the ALC circuit; recommended settings for each of these are given as a starting point for optimization.

VERSION 1					
WM8750	WM8750B	WM8753	WM8971	WM8973	WM8975
WM8987	WM9711	WM9712	WM9713	WM9714	
VERSION 2					
WM1400	WM8510	WM8758A	WM8758B	WM8940	WM8941
WM8950	WM8974	WM8976	WM8978	WM8980	WM8982
WM8983	WM8985				
VERSION 3					
WM8960					

In applications that offer a recording feature, it is often desirable to keep the recorded signal at a constant level. For example, if recording voice, the signal may vary a great deal depending on how loud the user speaks or how close to the mouth the microphone is held. This will result in a recorded signal that is difficult to listen to when played back.

The purpose of the ALC is to keep a constant output volume irrespective of the input signal level. This is achieved by continually adjusting the PGA gain so that the signal level at the ADC input remains constant.

Setting up the ALC to be optimal for each recorded source such as voice, classical music, pop music, etc. is quite a complex process. Recommended setups have been provided as a base to work from. The resultant effect is very subjective and may vary between applications. Some further modifications may be required to optimize the feature for a specific application but the recommended settings should offer suitable solutions in most cases.

**For a detailed explanation of the operation of the ALC refer to Application Note WAN\_0140.**

### CONTROLS

**ALC Enable / ALC Level.** The ALC/Limiter function is enabled by setting the register field ALCSEL. When enabled, the ALC output volume can be programmed using the ALCLVL or ALCL register field. The range of ALC Level varies between different Codec product families; values between -1.5dBFS and -28.5dBFS are available. The maximum target level is always below 0dB to help reduce the possibility of clipped signals.

**ALC Maximum Gain.** An upper limit for the PGA gain is imposed by setting the register field MAXGAIN or ALCMAXGAIN. This feature is useful in CD music record applications, where a track may fade out with ALC on; if there was no maximum PGA gain setting, then the signal would be gained up until either the end of the track was reached, or until the limit of the PGA was reached; in either case, the effect of fading out the track would be lost.

**ALC Minimum Gain.** On some ALCs, a lower limit for the PGA gain is imposed by setting the register field ALCMIN or MINGAIN. This enables the signal level to be maintained within a required gain range and prevent it from becoming too small for the application requirements.

**ALC Hold Time.** The time delay between the signal level detected below target level and the PGA gain beginning to ramp up is controlled by register field HLD or ALCHLD. It can be set to zero, or can be programmed in power-of-two ( $2^n$ ) steps, e.g. 2.67ms, 5.33ms, 10.67ms etc. up to 43.7s. Note that the ALC Hold Time only applies to gain ramp-up; there is no delay before ramping the gain down when the signal level is above target. The ALC Hold Time is not active in Limiter Mode (see below).

**ALC Decay Time.** The time taken by the ALC for ramp up the PGA gain is controlled by register field DCY or ALCDCY. The ALC Decay Time is defined as a time per gain step, time per 6dB change or a time to ramp up over 90% of the PGA range. It can be programmed in power-of-two ( $2^n$ ) steps, e.g. 3.3ms/6dB, 6.6ms/6dB, 13.1ms/6dB, etc up to 3.36s/6dB.

**ALC Attack Time.** The time taken by the ALC for ramp down the PGA gain is controlled by register field ATK or ALCATK. The ALC Attack Time is defined as a time per gain step, time per 6dB change or a time to ramp down over 90% of the PGA range. It can be programmed in power-of-two ( $2^n$ ) steps, e.g. 832us/6dB, 1.66ms/6dB, 3.328us/6dB, etc up to 852ms/6dB.

**ALC Mode.** On some ALCs, two modes of operation are available via register bit ALCMODE. Normal ALC operation is selected by setting ALCMODE = 0. Limiter Mode is selected by setting ALCMODE = 1. In Limiter mode, the ALC Maximum Gain is set equal to the PGA setting at the time that ALC Enable is set. In this mode, the signal level may be reduced to prevent overload, but may not be increased above the initial PGA gain setting - the register field MAXGAIN or ALCMAXGAIN are not used when Limiter Mode is selected. In Limiter mode, the gain control circuit runs approximately 4 times faster to allow quick reduction of high signal levels and to prevent clipping when long attack times are used. If the ALC Attack Time is set to zero, then the gain control runs at the same rate in both ALC and Limiter modes.

**Peak/Overload Limiter.** To avoid clipping when a large signal is applied just after a period where the PGA gain has been ramped up (eg. after a period of quiet), the ALC circuit includes a Peak/Overload Limiter function. If the ADC input signal exceeds 87.5% of full scale (-1.16dB), the PGA gain is ramped down at the maximum attack rate (as when ALCATK = 0000), until the signal level falls below 87.5% of full scale. This function is always enabled whenever the ALC is enabled.

**Sample Rate.** The ALC Hold, Decay and Attack times are constant across sample rates provided that the Sample Rate bits ADC\_ALC\_SR are set correctly. For example, when sampling at 48kHz, the ALC settings will only be correct if the Sample Rate bits are set to 000 (48kHz). If the actual sample rate was 44.1kHz and the ADC\_ALC\_SR bits were set to 48kHz, then the ALC Hold, Decay and Attack times would be scaled down by 44.1/48.

**ALC Zero Cross.** On some ALCs, the register field ALCZC may be used to control whether PGA gain updates are timed to occur at the zero-cross points of the input signal. Enabling this feature ensures that pops and clicks arising from the PGA gain adjustments are minimized, but this feature may also result in a slower ALC response.

**Noise Gate Enable / Noise Gate Threshold / Noise Gate Type.** The Noise Gate function is enabled by setting the register field NGAT or NGATEN. When enabled, the Noise Gate Threshold can be programmed using the NGTH register field. The range of Noise Gate Threshold varies between different Codec product families; this threshold is the input signal level below which the PGA gain will either be muted or be held constant. On some ALCs, the Noise Gate behaviour (Mute or Hold Gain) can be set by register field NGG.

## RECOMMENDED SETTINGS

Voice and music recording can be very different to each other. Music may contain both fast or slow changes in signal level, which an ALC must aim to preserve to a great extent. Voice signals may also be variable, and will differ from one person to another; in this case the ALC would normally aim to adapt the signal level to a much greater extent than the music ALC.

For voice recording, a fast decay time and short hold time are recommended so that the ALC responds quickly to a change in voice level. For music recording, the fast response is not recommended as it is likely to result in clipping in response to any sudden changes in the music signal level. A reduction in the maximum gain setting may help to avoid clipping when the music level increases after a quiet period and to restrict the extent of the ALC adjustments. This may not be desirable in all music applications and is therefore not shown in the recommended settings. It is one of the many adjustments that the user should consider when optimizing for a known operational environment.

When the ALC is optimized for a different type of signal to the signal that is applied, poor performance may be observed. An example of this is the ALC's response to an impulse, such as a handclap. If the ALC Attack Time is short, then the ALC will respond to the handclap by rapidly reducing the PGA gain, with the possibility that the following signal will be too heavily attenuated. This will be particularly noticeable if the ALC Decay Time is slow. For an ALC response that is tolerant to impulses such as handclaps, it is recommended that the ALC Attack time should not be set below 192ms and the ALC Decay time should not be set above 192ms.

Recommended settings are provided for voice record, music record and a 'general' setting that is designed to be tolerant to impulses such as handclaps. It is emphasized that these are suggested initial values only, as a starting point from which to derive the best settings for a particular circuit application.

The settings in Table 1, Table 2 and Table 3 are recommended starting values for the following devices:

VERSION 1					
WM8750	WM8750B	WM8753	WM8971	WM8973	WM8975
WM8987	WM9711	WM9712	WM9713	WM9714	

The recommended settings for voice record are shown in Table 1.

REGISTER BIT	RECOMMENDED VALUE
ALCSEL [1:0]	11 (Stereo)
ALCZC	0 (ZC off)
MAXGAIN [2:0]	111 (+30dB)
ALCL [3:0]	1011 (-12dB)
HLD [3:0]	0000 (0ms)
DCY [3:0]	0100 (384ms)
ATK [3:0]	0010 (24ms)
NGG [1:0]	00 or 10 (hold gain)
NGAT	1 (enabled)
NGTH [4:0]	00000 (-76.5dB)

**Table 1 Recommended Voice Record Settings**

The recommended settings for music record are shown in Table 2.

REGISTER BIT	RECOMMENDED VALUE
ALCSEL [1:0]	11 (Stereo)
ALCZC	1 (ZC on)
MAXGAIN [2:0]	111 (+30dB)
ALCL [3:0]	1011 (-12dB)
HLD [3:0]	0000 (0ms)
DCY [3:0]	1010 (24.58s)
ATK [3:0]	0110 (384ms)
NGG [1:0]	00 or 10 (hold gain)
NGAT	1 (enabled)
NGTH [4:0]	00000 (-76.5dB)

**Table 2 Recommended Music Record Settings**

The recommended settings for impulse (hand clap) record are shown in Table 3.

REGISTER BIT	RECOMMENDED VALUE
ALCSEL [1:0]	11 (Stereo)
ALCZC	1 (ZC on)
MAXGAIN [2:0]	111 (+30dB)
ALCL [3:0]	1011 (-12dB)
HLD [3:0]	0000 (0ms)
DCY [3:0]	0101 (192ms)
ATK [3:0]	0010 (192ms)
NGG [1:0]	00 or 10 (hold gain)
NGAT	1 (enabled)
NGTH [4:0]	00000 (-76.5dB)

**Table 3 Recommended Impulse (Hand Clap) Record Settings**

The settings in Table 4, Table 5 and Table 6 are recommended starting values for the following devices:

VERSION 2					
WM1400	WM8510	WM8758A	WM8758B	WM8940	WM8941
WM8950	WM8974	WM8976	WM8978	WM8980	WM8982
WM8983	WM8985				

The recommended settings for voice record are shown in Table 4.

REGISTER BIT	RECOMMENDED VALUE
ALCMODE	0 (ALC)
ALCSEL [1:0]	11 (Stereo)
ALCZC	0 (ZC off)
ALCMAX [2:0]	111 (+35.25dB)
ALCMIN [2:0]	000 (-12dB)
ALCLVL [3:0]	0111 (-12dB)
ALCHLD [3:0]	0000 (0ms)
ALCDCY [3:0]	0100 (384ms)
ALCATK [3:0]	0010 (24ms)
NGATEN	1 (enabled)
NGTH [2:0]	111 (-81dB)

**Table 4 Recommended Voice Record Settings**

The recommended settings for music record are shown in Table 5.

REGISTER BIT	RECOMMENDED VALUE
ALCMODE	0 (ALC)
ALCSEL [1:0]	11 (Stereo)
ALCZC	1 (ZC on)
ALCMAX [2:0]	111 (+35.25dB)
ALCMIN [2:0]	000 (-12dB)
ALCLVL [3:0]	0111 (-12dB)
ALCHLD [3:0]	0000 (0ms)
ALCDCY [3:0]	1010 (24.2s)
ALCATK [3:0]	0110 (384ms)
NGATEN	1 (enabled)
NGTH [2:0]	111 (-81dB)

**Table 5 Recommended Music Record Settings**

The recommended settings for impulse (hand clap) record are shown in Table 6.

REGISTER BIT	RECOMMENDED VALUE
ALCMODE	0 (ALC)
ALCSEL [1:0]	11 (Stereo)
ALCZC	1 (ZC on)
ALCMAX [2:0]	111 (+35.25dB)
ALCMIN [2:0]	000 (-12dB)
ALCLVL [3:0]	0111 (-12dB)
ALCHLD [3:0]	0000 (0ms)
ALCDCY [3:0]	0011 (192ms)
ALCATK [3:0]	0101 (192ms)
NGATEN	1 (enabled)
NGTH [2:0]	111 (-81dB)

**Table 6 Recommended Impulse (Hand Clap) Record Settings**

The settings in Table 7, Table 8 and Table 9 are recommended starting values for the following devices:

VERSION 3	
WM8960	

The recommended settings for voice record are shown in Table 7.

REGISTER BIT	RECOMMENDED VALUE
ALCMODE	0 (ALC)
ALCSEL [1:0]	11 (Stereo)
MAXGAIN [2:0]	111 (+30dB)
MINGAIN [2:0]	000 (-17.25dB)
ALCL [3:0]	0111 (-12dB)
HLD [3:0]	0000 (0ms)
DCY [3:0]	0100 (384ms)
ATK [3:0]	0010 (24ms)
NGAT	1 (enabled)
NGTH [4:0]	00000 (-76.5dB)

**Table 7 Recommended Voice Record Settings**

The recommended settings for music record are shown in Table 8.

REGISTER BIT	RECOMMENDED VALUE
ALCMODE	0 (ALC)
ALCSEL [1:0]	11 (Stereo)
MAXGAIN [2:0]	111 (+30dB)
MINGAIN [2:0]	000 (-17.25dB)
ALCL [3:0]	0111 (-12dB)
HLD [3:0]	0000 (0ms)
DCY [3:0]	1010 (24.2s)
ATK [3:0]	0110 (384ms)
NGAT	1 (enabled)
NGTH [4:0]	00000 (-76.5dB)

**Table 8 Recommended Music Record Settings**

The recommended settings for impulse (hand clap) record are shown in Table 9.

REGISTER BIT	RECOMMENDED VALUE
ALCMODE	0 (ALC)
ALCSEL [1:0]	11 (Stereo)
MAXGAIN [2:0]	111 (+30dB)
MINGAIN [2:0]	000 (-17.25dB)
ALCL [3:0]	0111 (-12dB)
HLD [3:0]	0000 (0ms)
DCY [3:0]	0011 (192ms)
ATK [3:0]	0101 (192ms)
NGAT	1 (enabled)
NGTH [4:0]	00000 (-76.5dB)

**Table 9 Recommended Impulse (Hand Clap) Record Settings**

**Notes:**

1. The recommended register settings shown in Table 4, Table 5 and Table 6 above are for Stereo devices. Refer to the device datasheet for the exact register settings.
2. Although the register values may be different for other Wolfson portable devices supporting ALC, the 'real' values suggested are still valid.
3. The settings for voice record, music record, and hand clap record have been decided upon by listening tests and are very subjective; different users will have their own preferences but these settings should provide acceptable performance and a base to work from to optimise a specific application.

## TROUBLESHOOTING

### THE OUTPUT SIGNAL IS BEING CLIPPED

It is unlikely that clipping will occur as the maximum target level of the ALC is set so that the chances of a clipped signal are very small. If however clipping does occur, the most likely solution will be to reduce the ALC Maximum Gain setting.

### THE SIGNAL LEVEL IS TOO SMALL

If the signal level appears to be too small or is taking a long time to reach an expected level, the ALC Maximum Gain setting should be increased to allow the ALC signal to be gained more. If the signal is taking some time to reach an expected level, the ALC Hold Time should be shortened and/or the ALC Decay Time.

### DURING VERY LOW LEVEL OR NO AUDIO INPUT A 'PULSING' EFFECT CAN BE HEARD

The Noise Gate function should be set active in this case. The pulsing effect is caused by the ALC trying to pull the signal to the set state.

For a more detailed list refer to WAN\_0140.

## SUMMARY/CONCLUSION

The purpose of this application note is to simplify the setup of the ALC feature offered by many of Wolfson's Codecs and ADCs.

Recommended setups have been provided as a base to work from for new users. The resultant effect is very subjective and may vary between applications. Some further modifications may be required to optimize the feature for a specific application but the recommended settings should offer suitable solutions in most cases.

Specific device datasheets should be referred to for register settings and any additional functions not discussed in this document when setting up the ALC feature.

## **APPLICATION SUPPORT**

If you require more information or require technical support, please contact the Wolfson Microelectronics Applications group through the following channels:

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