WAN_0141

WM8750/51L and WM9711/12L Speaker Drivers

INTRODUCTION

The WM8750/51L and WM9711/12L portable codec devices incorporate output stage drivers capable of driving either mono or stereo speakers. The WM8750/51L and WM9711/12L setup and external component arrangements are explained below for various speaker configurations. The maximum power output available is limited by the drive capability of the device output stages and the impedance of the speaker being used. It is possible to employ an external power amp to boost the output power and a suggested arrangement is detailed below.

MAXIMUM POWER DEVELOPMENT

Prior to examining specific device or speaker configurations it may be useful to re-cap on the limitations that will be met when implementing speakers. This section is to remind the reader of the factors that need to be considered for maximum power output.

Maximum power that can be developed by the speakers depend upon a number of factors:

1. Speaker load impedance. The greater the speaker impedance the less power that will be developed for the same output voltage. $P = V_{rms}^2/R$
2. Codec device output drive capability. This will be limited by the internal output stage op-amp drive capability and the supply voltage used. The WM8750/51L and WM9711/12L are limited to a maximum speaker drive of 500mW into 8Ω and headphone drive of 60mW into 16 Ω.
3. Type of output coupling. AC coupling may be required dependent upon speaker configuration, High ESR capacitors may limit power.
4. The number of speakers required. For example, single-ended stereo speakers will develop a combined total of half the power of a differential mono speaker of the same impedance.
5. Speaker configuration. There are four speaker configurations available to the WM8750/51L and WM9711/12L: single-ended mono, differential mono, single-ended stereo or differential stereo using an external speaker. Each of these configurations will develop different maximum powers, even using the same speaker impedance and output voltage.
6. Analogue power supplies voltages. The WM8750/51L and WM9711/12L are capable of operating with a range of supply voltages, particularly relevant here are the SPKVDD, AVDD and HPVDD supply voltages. The lower the supply voltage used the smaller the maximum output voltage and the less power that can developed into the speaker.
7. In relation to the previous point, increasing SPKVDD or HPVDD alone will not increase the maximum output power of the device. The maximum signal output voltage of the ADC is determined by AVDD. Increasing AVDD as well as SPKVDD or HPVDD (within device limits) will allow an increase in output power.
8. Although not a physical limitation, further practical considerations need to be examined such as acceptable distortion levels. The WM8750/51L and WM9711/12L will give THD+N measurements of greater than 4% at 500mW but 0.1% at 180mW output.

WM8750/51L SETUP

LOUT2/ROUT2 REGISTER SETTINGS

The LOUT2 and ROUT2 output pins are independently controlled and can drive an 8Ω mono speaker. For differential mono speaker driving, the ROUT2 signal must be inverted (ROUT2INV = 1), the left and right channel are mixed to mono in the speaker [L–(-R) = L+R].

REGISTER ADDRESS	BIT	LABEL	DEFAULT	DESCRIPTION
R40 (28h) LOUT2 Volume	6:0	LOUT2VOL [6:0]	1111001 (0dB)	LOUT2 Volume 1111111 = +6dB … (80 steps) 0110000 = -67dB 0101111 to 0000000 = Analogue MUTE
	7	LO2ZC	0	Left zero cross enable 1 = Change gain on zero cross only 0 = Change gain immediately
	8	LO2VU	0	Left Volume Update 0 = Store LOUT2VOL in intermediate latch (no gain change) 1 = Update left and right channel gains (left = LOUT2VOL, right = intermediate latch)
R41 (29h) ROUT2 Volume	6:0	ROUT2VOL [6:0]	1111001 (0dB)	ROUT2 Volume 1111111 = +6dB … (80 steps) 0110000 = -67dB 0101111 to 0000000 = Analogue MUTE
	7	RO2ZC	0	Right zero cross enable 1 = Change gain on zero cross only 0 = Change gain immediately
	8	RO2VU	0	Right Volume Update 0 = Store ROUT2VOL in intermediate latch (no gain change) 1 = Update left and right channel gains (left = intermediate latch, right = ROUT2VOL)
R24 (18h) Additional Control (2)	4	ROUT2INV	0	ROUT2 Invert 0 = No Inversion (0° phase shift) 1 = Signal inverted (180° phase shift)

Table 1 WM8750/51L L/ROUT2 Control

Note:

1. For BTL speaker drive, it is recommended that LOUT2VOL = ROUT2VOL.

DIFFERENTIAL MONO SPEAKER OUTPUT

LOUT2 and ROUT2 of the WM8750/51L can differentially drive a mono 8Ω speaker as shown below.

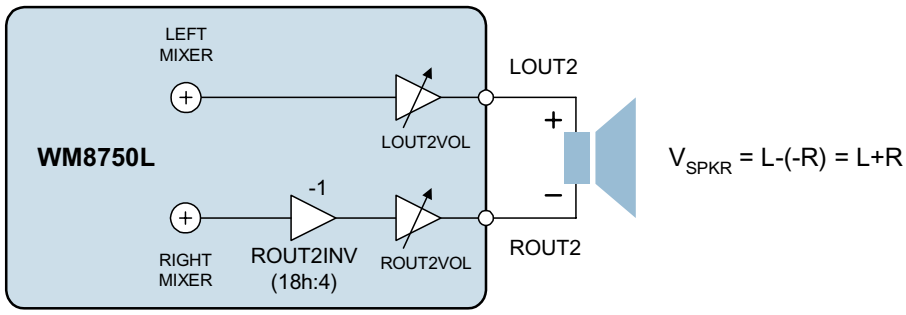

Figure 1 WM8750/51L Differential Mono Speaker Output Connection

The right channel is inverted by setting the ROUT2INV bit, so that the signal across the loudspeaker is the sum of left and right channels.

Maximum output per channel of LOUT2 and ROUT2 (AVDD = HPVDD = 3.3V) is 1Vrms. With the right channel inverted the speaker inputs are differential and the maximum total voltage across the speaker is 2Vrms. Therefore $P = V^2 / R = 2^2 / 8 = 500mW$. In practical terms this is limited to 400mW before distortion increases significantly, which corresponds to a maximum output PGA gain setting of -1dB with a 0dBV input signal.

Larger powers can be developed into this mono configuration by using an external power amp; a device such as the National Semiconductors LM4895 from the Boomer® series would be suitable. However, in order to get more power, higher supply voltages enabling bigger signal swings must be used. A 4Ω speaker could be used but distortion will be worse and power dissipation may become an issue.

WM9711/12L SETUP

LOUT2 AND ROUT2 REGISTER SETTINGS

The LOUT2 and ROUT2 output pins are independently controlled and can drive an 8Ω mono speaker. For speaker drive, the ROUT2 signal must be inverted (INV = 1), so that the left and right channel are mixed to mono in the speaker [L–(-R) = L+R].

REGISTER ADDRESS	BIT	LABEL	DEFAULT	DESCRIPTION
02h LOUT2/ROUT2 Volume	15	MUTE	1	Mute LOUT2 and ROUT2 1: Mute (OFF) 0: No Mute (ON)
	13:8	LOUT2VOL	00000 (0dB)	LOUT2 Volume 000000: 0dB (maximum) 000001: -1.5dB … (1.5dB steps) 011111: -46.5dB 1xxxxx: -46.5dB
	7	ZC	0	Zero Cross Enable 0: Change gain immediately 1: Change gain only on zero crossings, or after time-out
	6	INV	0	LOUT2 Invert 0 = No Inversion (0° phase shift) 1 = Signal inverted (180° phase shift)
	5:0	ROUT2VOL	00000 (0dB)	ROUT2 Volume 000000: 0dB (maximum) 000001: -1.5dB … (1.5dB steps) 011111: -46.5dB 1xxxxx: -46.5dB
16h	8	SRC	0	Source of LOUT2/ROUT2 signals 0: speaker mixer (for BTL speaker) 1: headphone mixer (for stereo output)

Table 2 WM9711/12L LOUT2 / ROUT2 Control

Note:

1. For BTL speaker drive, it is recommended that LOUT2VOL = ROUT2VOL.

DIFFERENTIAL MONO SPEAKER OUTPUT

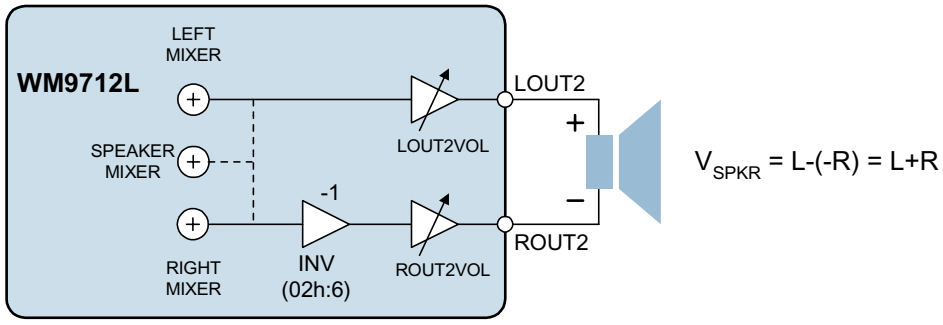

Figure 2 WM9711/12L Mono Speaker Output Connection

The right channel is inverted by setting the INV bit, so that the signal across the loudspeaker is the sum of left and right channels. The WM9711/12L output signals can originate from the headphone mixer or the speaker mixer. There is only a single speaker mixer, which can be configured to direct the signal to both LOUT2 and ROUT2. The headphone mixer must be configured so that the same signal is present at both LOUT2 and ROUT2 outputs but with the ROUT2 output inverted as set by the INV bit in Table 2.

Maximum output per channel of LOUT2 and ROUT2 (AVDD = SPKVDD = 3.3V) is 1Vrms. As the speaker is differential the total voltage across the speaker is 2Vrms. Therefore $P = V^2 / R = 2^2 / 8 =$ 500mW. In practical terms this is limited to 400mW before distortion increases significantly, which corresponds to a maximum output PGA gain setting of approximately -1.5dB with a 0dBV input signal.

SPEAKER MIXER

In the WM9711/12L the speaker mixer can drive the LOUT2 and ROUT2 output; refer to latest revision of the device datasheet for details. The following signals can be mixed into the speaker path:

- PHONE (Register 0Ch)[1]
- LINE_IN (Register 10h)[1]
- The stereo DAC signal (Register 18h) [2]
- PC_BEEP (Register 0Ah)[1]
- The AUXDAC signal (Register 12h)[3]

Notes:

1. Refer “Audio Inputs” section in WM9711/12L datasheet.
2. Refer “Audio DACs” section in WM9711/12L datasheet.
3. Refer “Auxiliary DAC” section in WM9711/12L datasheet.

In a typical smartphone application, the speaker signal is a mix of AUXDAC (for system alerts or ring tone playback), PHONE (for speakerphone function), and PC_BEEP (for externally generated ring tones).

WM8750/51L AND WM9711/12L EAR SPEAKER OUTPUT – OUT3

The OUT3 pin can drive a 16Ω or 32Ω headphone or a line output or be used as a DC reference for a headphone output. It can be selected to either drive out an inverted ROUT1 or inverted MONOOUT for e.g. an earpiece (phone receiver) drive between OUT3 and LOUT1 or differential output between OUT3 and MONOOUT.

The speaker can be connected differentially between OUT3 and HPOUTL, or in single-ended configuration (OUT3 to HPGND). The ear speaker output is produced by the headphone mixer. The right signal must be inverted (OUT3INV = 1), so that the left and right channel are mixed to mono in the speaker [L–(-R) = L+R].

The maximum output per channel of HPOUTL and OUT3 with large load impedance (AVDD = HPVDD = 3.3V) is 1Vrms. The output op-amps are headphone drivers and have limited drive capability. It is not possible here to drive a differential speaker voltage of 2Vrms into a small load (16Ω) as is possible with LOUT2 and ROUT2. The output power here is limited to 60mW, which corresponds to a maximum output PGA gain setting of -6dB with a 0dBV input signal.

OUT3SW selects the mode of operation required.

REGISTER ADDRESS	BIT	LABEL	DEFAULT	DESCRIPTION
R24 (18h) Additional Control (2)	8:7	OUT3SW [1:0]	00	OUT3 select 00 : VREF 01 : ROUT1 signal (volume controlled by ROUT1VOL) 10 : MONOOUT 11 : right mixer output (no volume control through ROUT1VOL)

Table 3 WM8750/51L OUT3 Select

REGISTER ADDRESS	BIT	LABEL	DEFAULT	DESCRIPTION
16h OUT3 Control	15	MUTE	1	Mute OUT3 1: Mute (Buffer OFF) 0: No Mute (Buffer ON)
	10:9	OUT3 SRC	00	Source of OUT3 signal 00 inverse of HPOUTR (for BTL ear speaker) 01 VREF (for capless headphone drive) 10 mono mix of both headphone channels (for single-ended ear speaker) 11 inverse of MONOOUT (for differential mono output)
	7	ZC	0	Zero Cross Enable 0: Change gain immediately 1: Change gain only on zero crossings, or after time-out
	5:0	OUT3 VOL	000000 (0dB)	OUT3 Volume 000000: 0dB (maximum) 000001: -1.5dB … (1.5dB steps) 011111: -46.5dB 1xxxxx: -46.5dB

Table 4 WM9711/12L OUT3 Control

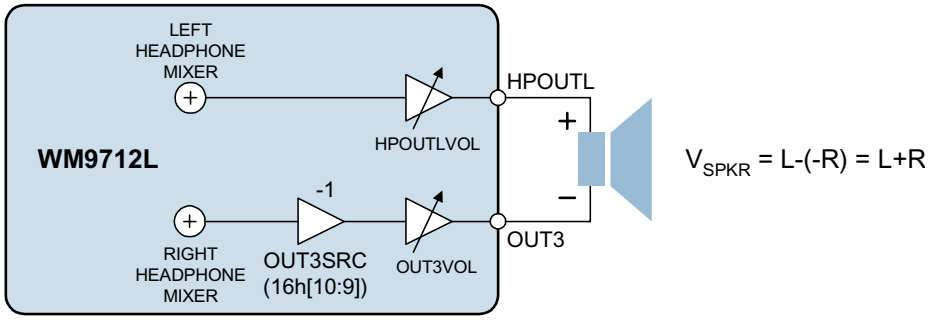

Figure 3 Differential Mono Speaker Configuration Using OUT3

OUT3 has two additional functions but can only handle one function at any given time. It can be used to eliminate the DC blocking capacitors on HPOUTL and HPOUTR by producing a buffered midrail voltage (AVDD/2) that is connected to the headphone socket ground pin.

OUT3 can also produce the inverse of the MONOOUT signal, for use with a differential mono output. In this mode when used with MONOOUT, these outputs are not designed to drive a speaker only a much larger line level load.

In the WM9711/12L it is possible to use the OUT3VOL control in conjunction with the MONOOUTVOL control to vary the differential gain of the OUT3 to MONOOUT differential configuration. The WM8750/51L is more limited in that the MONOOUTVOL control must be set to the +6dB gain setting to produce a 0dB gain output. Both OUT3 and MONOOUT will then have equal 0dB output gains; this is due to the internal structure of the device. Refer to the datasheet for further information.

SINGLE-ENDED STEREO SPEAKER CONFIGURATION

Both the WM8750/51L and WM9711/12L can be configured with stereo speakers but this reduces the maximum power output to 125mW per channel in single-ended configuration.

Maximum output per channel of LOUT2 and ROUT2 (AVDD = SPKVDD/HPVDD = 3.3V) is 1Vrms. As each speaker is in single-ended configuration the voltage across each speaker is 1Vrms. Therefore $P = V^2 / R = 1^2 / 8 = 125mW$. In practical terms this is limited to 100mW before distortion increases significantly, which corresponds to a maximum output PGA gain setting of -1dB on the WM8750/51L or -1.5dB on the WM9711/12L with a 0dBV input signal.

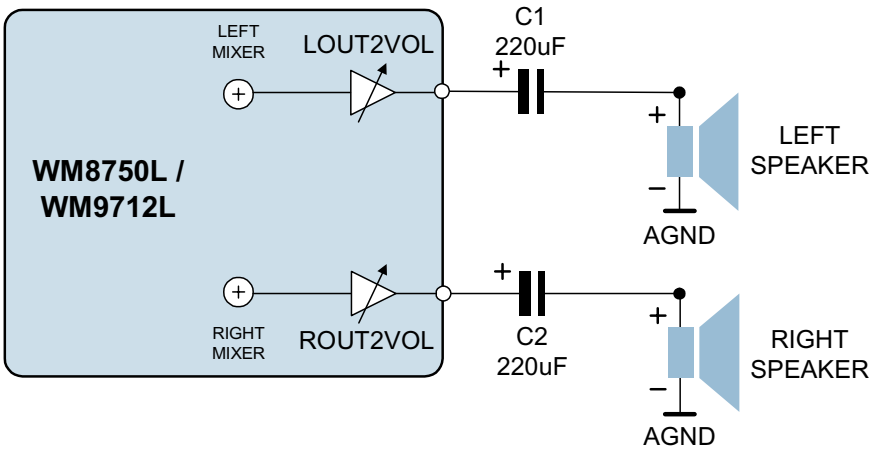

Figure 4 Single-ended Stereo Speakers

The DC blocking capacitors and the load resistance together determine the lower cut-off frequency, f_c. Assuming an 8Ω load and C1, C2 = 220µF:

$f_c = 1 / 2\pi (R_L) C_1 = 1 / (2\pi \times 8\Omega \times 220\mu F) = 180$ Hz

Increasing the capacitance lowers f_c, improving the bass response but this also increases the size of capacitor. Large capacitors may be unacceptable for certain designs. Smaller values of C1 and C2 will diminish the bass response. A compromise must be reached between acceptable bass response and space/cost considerations. Refer WAN0121 for further details on the Role of the Headphone Coupling Capacitor http://www.wolfsonmicro.com/uploads/documents/WAN_0121.pdf

STEREO DIFFERENTIAL SPEAKER CONFIGURATION

As previously discussed, both the WM8750/51L and WM9711/12L can be configured with stereo speakers, but each channel is reduced to a maximum power output to 125mW per channel.

Maximum output per channel of LOUT2 and ROUT2 (AVDD = SPKVDD/HPVDD = 3.3V) is 1Vrms. As each speaker is in single-ended configuration the voltage across each speaker is 1Vrms. Therefore $P = V^2 / R = 1^2 / 8 = 125mW$. Again in practical terms this is limited to 100mW before distortion increases significantly, this correspond to a maximum output PGA gain setting of -1dB on the WM8750/51L and -1.5dB on the WM9711/12L with a 0dBV input signal.

In some applications, it may sometimes be necessary to increase the maximum output power requirements or to operate the WM8750/51L and WM9711/12L at an output level where distortion is minimised. The best method to achieve these requirements is by the use of an external speaker driver.

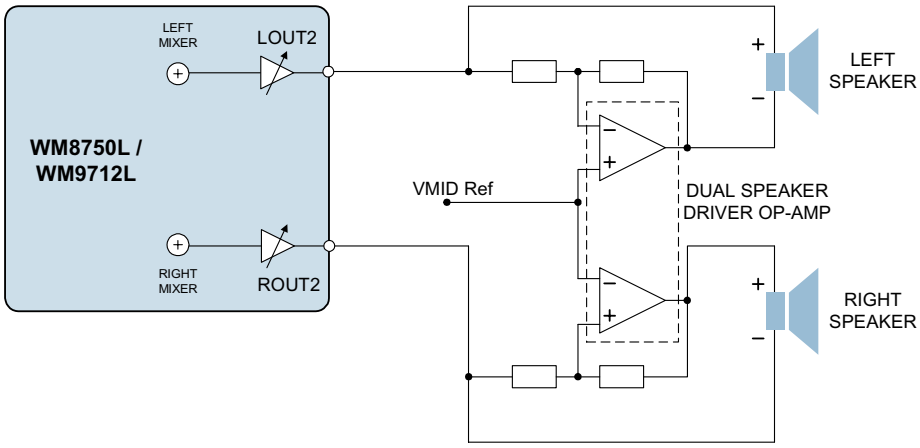

Figure 5 Differential Stereo Speaker Configuration with External Op-amp Drivers

The suggested power amp layout described in Figure 5 shows a generic Dual Speaker Driver Op-amp. The VMID reference shown can either taken from the CAP2 pin on the WM9711/12L, the VREF pin on the WM8750/51L or from elsewhere in the customer application. In this scenario each differentially driven speaker will output 0.5Wrms on a 3.3V supply, assuming the external amplifier chosen is able to supply this power load.

No specific op-amp driver can be recommended but the following devices are suitable suggestions to increase power output.

1. National Semiconductors LM4895 from the Boomer® series.
   http://cache.national.com/ds/LM/LM4880.pdf
2. Texas Instruments TPA6116. http://focus.ti.com/lit/ds/symlink/tpa0202.pdf

SUMMARY

The WM8750/51L and WM9711/12L can provide sufficient speaker drive capability suitable for most portable applications. It is possible to drive various speaker configurations in either single-ended mode or differential mode by inverting ROUT2. Applications using stereo speaker outputs may require additional power amplification to provide sufficient sound levels or to prevent distortion when the outputs of the WM8750/51L and WM9711/12L devices are driven hard.

APPLICATION SUPPORT

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

Email: apps@wolfsonmicro.com
Telephone Apps: (+44) 131 272 7070
Fax: (+44) 131 272 7001
Mail: Applications at the address on the last page.

or contact your local Wolfson representative.

Additional information may be made available from time to time on our web site at http://www.wolfsonmicro.com

IMPORTANT NOTICE

Wolfson Microelectronics plc (WM) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current. All products are sold subject to the WM terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability.

WM warrants performance of its products to the specifications applicable at the time of sale in accordance with WM's standard warranty. Testing and other quality control techniques are utilised to the extent WM deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

In order to minimise risks associated with customer applications, adequate design and operating safeguards must be used by the customer to minimise inherent or procedural hazards. Wolfson products are not authorised for use as critical components in life support devices or systems without the express written approval of an officer of the company. Life support devices or systems are devices or systems that are intended for surgical implant into the body, or support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided, can be reasonably expected to result in a significant injury to the user. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

WM assumes no liability for applications assistance or customer product design. WM does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of WM covering or relating to any combination, machine, or process in which such products or services might be or are used. WM's publication of information regarding any third party's products or services does not constitute WM's approval, license, warranty or endorsement thereof.

Reproduction of information from the WM web site or datasheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations and notices. Representation or reproduction of this information with alteration voids all warranties provided for an associated WM product or service, is an unfair and deceptive business practice, and WM is not responsible nor liable for any such use.

Resale of WM's products or services with statements different from or beyond the parameters stated by WM for that product or service voids all express and any implied warranties for the associated WM product or service, is an unfair and deceptive business practice, and WM is not responsible nor liable for any such use.

ADDRESS:

Wolfson Microelectronics plc

Westfield House

26 Westfield Road

Edinburgh

EH11 2QB

United Kingdom

Tel :: +44 (0)131 272 7000

Fax :: +44 (0)131 272 7001

Email :: sales@wolfsonmicro.com