



# 24-bit, 192kHz Stereo DAC

## DESCRIPTION

The WM8729 is a high performance stereo DAC designed for audio applications such as DVD, home theatre systems, and digital TV. The WM8729 supports data input word lengths from 16 to 24-bits and sampling rates up to 192kHz. The WM8729 consists of a serial interface port, digital interpolation filters, multi-bit sigma delta modulators and stereo DAC in a small 16-pin SOIC package.

The WM8729 has a hardware control interface for selection of audio data interface format and de-emphasis.

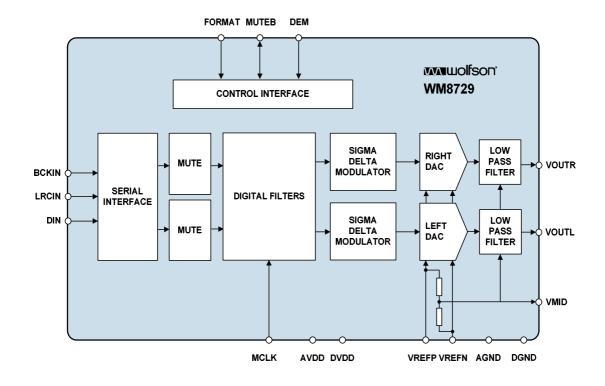
The WM8729 is an ideal device to interface to AC-3<sup>TM</sup>, DTS<sup>TM</sup>, and MPEG audio decoders for surround sound applications, or for use in DVD players, including supporting the implementation of 2 channels at 192kHz for high-end DVD-Audio applications.

## **FEATURES**

- Stereo DAC
- Audio Performance
  - 106dB SNR ('A' weighted @ 48kHz) DAC
     -97dB THD
  - DAC Sampling Frequency: 8kHz 192kHz
- Pin Selectable Audio Data Interface Format
- 3.0V 5.5V Supply Operation
- 16-lead SOIC Package
- To-lead SOIC Package
- Exceeds Dolby Class A Performance Requirements

#### APPLICATIONS

- DVD-Audio and DVD 'Universal' Players
- Home theatre systems
- Digital TV
- Digital broadcast receivers



# **BLOCK DIAGRAM**

#### WOLFSON MICROELECTRONICS plc

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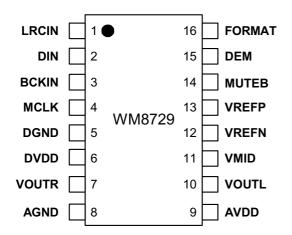
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# **PIN CONFIGURATION**



# **ORDERING INFORMATION**

DEVICE	TEMPERATURE RANGE	PACKAGE	MOISTURE SENSITIVITY LEVEL	PEAK SOLDERING TEMPERATURE
WM8729GED/V	-25 to +85°C	16-lead SOIC (Pb-free)	MSL2	260°C
WM8729GED/RV	-25 to +85°C	16-lead SOIC (Pb-free, tape and reel)	MSL2	260°C

Note:

Reel Quantity = 3,000



# **PIN DESCRIPTION**

PIN	NAME	TYPE	DESCRIPTION
1	LRCIN	Digital Input	DAC Sample Rate Clock Input
2	DIN	Digital Input	Serial Audio Data Input
3	BCKIN	Digital Input	Audio Data Bit Clock Input.
4	MCLK	Analogue Input	Master Clock Input
5	DGND	Supply	Digital Ground Supply
6	DVDD	Supply	Digital Positive Supply
7	VOUTR	Analogue Output	Right Channel DAC Output
8	AGND	Supply	Analogue Ground Supply
9	AVDD	Supply	Analogue Positive Supply
10	VOUTL	Analogue Output	Left Channel DAC Output
11	VMID	Analogue Output	Mid Rail Decoupling Point
12	VREFN	Supply	DAC Negative Reference – normally AGND, must not be below AGND
13	VREFP	Supply	DAC Positive Reference – normally AVDD, must not be above AVDD
14	MUTEB	Digital Bi-directional	Mute Control, (L = Mute on, H = Mute off, Z = Automute Enabled)
15	DEM	Digital Input	De-Emphasis Select
			0 = De-Emphasis Off
			1 = De-Emphasis On
16	FORMAT	Digital Input	Digital Audio Data Input Format Selection
		(Pull-Up)	0 = Right justified Audio Data
			1 = I <sup>2</sup> S Audio Data

Note:

Digital input pins have Schmitt trigger input buffers.



# **ABSOLUTE MAXIMUM RATINGS**

Absolute Maximum Ratings are stress ratings only. Permanent damage to the device may be caused by continuously operating at or beyond these limits. Device functional operating limits and guaranteed performance specifications are given under Electrical Characteristics at the test conditions specified.



ESD Sensitive Device. This device is manufactured on a CMOS process. It is therefore generically susceptible to damage from excessive static voltages. Proper ESD precautions must be taken during handling and storage of this device.

Wolfson tests its package types according to IPC/JEDEC J-STD-020B for Moisture Sensitivity to determine acceptable storage conditions prior to surface mount assembly. These levels are:

$$\label{eq:MSL1} \begin{split} & \text{MSL1} = \text{unlimited floor life at } <30^\circ\text{C} \ / \ 85\% \ \text{Relative Humidity. Not normally stored in moisture barrier bag.} \\ & \text{MSL2} = \text{out of bag storage for 1 year at } <30^\circ\text{C} \ / \ 60\% \ \text{Relative Humidity. Supplied in moisture barrier bag.} \\ & \text{MSL3} = \text{out of bag storage for 168 hours at } <30^\circ\text{C} \ / \ 60\% \ \text{Relative Humidity. Supplied in moisture barrier bag.} \\ \end{aligned}$$

The Moisture Sensitivity Level for each package type is specified in Ordering Information.

CONDITION	MIN	МАХ
Digital supply voltage	-0.3V	+7V
Analogue supply voltage	-0.3V	+7V
Voltage range digital inputs	DGND -0.3V	DVDD +0.3V
Voltage range analogue inputs	AGND -0.3V	AVDD +0.3V
Master Clock Frequency		50MHz
Operating temperature range, T <sub>A</sub>	-25°C	+85°C
Storage temperature	-65°C	+150°C

#### Note:

Analogue and digital grounds must always be within 0.3V of each other.



# **DC ELECTRICAL CHARACTERISTICS**

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Digital supply range	DVDD		3.0		5.5	V
Analogue supply range	AVDD		3.0		5.5	V
Ground	AGND, DGND			0		V
Difference DGND to AGND			-0.3	0	+0.3	V
Analogue supply current		AVDD = 5V		19		mA
Digital supply current		DVDD = 5V		8		mA
Analogue supply current		AVDD = 3.3V		18		mA
Digital supply current		DVDD = 3.3V		4		mA

# **ELECTRICAL CHARACTERISTICS**

### **Test Conditions**

AVDD, DVDD = 5V, AGND = 0V, DGND = 0V,  $T_A$  = +25°C, fs = 48kHz, MCLK = 256fs unless otherwise stated.

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Digital Logic Levels (TTL Levels	)					
Input LOW level	VIL				0.8	V
Input HIGH level	VIH		2.0			V
Output LOW	V <sub>OL</sub>	I <sub>OL</sub> = 1mA			DGND + 0.3V	V
Output HIGH	V <sub>OH</sub>	I <sub>OH</sub> = 1mA	DVDD - 0.3V			V
Analogue Reference Levels					•	
Reference voltage		VMID	(VREFP - VREFN)/2 - 50mV	(VREFP - VREFN)/2	(VREFP - VREFN)/2 + 50mV	V
Potential divider resistance	R <sub>VMID</sub>			12k		Ω
DAC Output (Load = 10kΩ. 50pF)		·				
0dBFs Full scale output voltage		At DAC outputs		1.1 x AVDD/5		Vrms
SNR (Note 1,2,3)		A-weighted, @ fs = 48kHz	100	106		dB
SNR (Note 1,2,3)		A-weighted @ fs = 96kHz		106		dB
SNR (Note 1,2,3)		A-weighted @ fs = 192kHz		106		dB
SNR (Note 1,2,3)		A-weighted, @ fs = 48kHz AVDD, DVDD = 3.3V		105		dB
SNR (Note 1,2,3)		A-weighted @ fs = 96kHz AVDD, DVDD = 3.3V		103		dB
SNR (Note 1,2,3)		Non 'A' weighted @ fs = 48kHz		106		dB
THD (Note 1,2,3)		1kHz, 0dBFs		-97		dB
THD+N (Dynamic range, Note 2)		1kHz, -60dBFs	100	106		dB
DAC channel separation				100		dB
Analogue Output Levels						
Output level		Load = $10k\Omega$ , 0dBFS		1.1		V <sub>RMS</sub>
		Load = $10k\Omega$ , 0dBFS, (AVDD = 3.3V)		0.726		$V_{\text{RMS}}$
Gain mismatch channel-to-channel				±1		%FSR



#### Test Conditions

AVDD, DVDD = 5V, AGND = 0V, DGND = 0V, T<sub>A</sub> = +25°C, fs = 48kHz, MCLK = 256fs unless otherwise stated.

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Minimum resistance load		To midrail or a.c. coupled		1		kΩ
		To midrail or a.c. coupled (AVDD = 3.3V)		600		Ω
Maximum capacitance load		5V or 3.3V		100		pF
Output d.c. level				(VREFP - VREFN)/2		V
Power On Reset (POR)						
POR threshold				2.4		V

#### Notes:

- 1. Ratio of output level with 1kHz full scale input, to the output level with all zeros into the digital input, measured 'A' weighted over a 20Hz to 20kHz bandwidth.
- 2. All performance measurements done with 20kHz low pass filter, and where noted an A-weight filter. Failure to use such a filter will result in higher THD+N and lower SNR and Dynamic Range readings than are found in the Electrical Characteristics. The low pass filter removes out of band noise; although it is not audible it may affect dynamic specification values.
- 3. VMID decoupled with 10uF and 0.1uF capacitors (smaller values may result in reduced performance).

### TERMINOLOGY

- 1. Signal-to-noise ratio (dB) SNR is a measure of the difference in level between the full scale output and the output with no signal applied. (No Auto-zero or Automute function is employed in achieving these results).
- Dynamic range (dB) DNR is a measure of the difference between the highest and lowest portions of a signal. Normally a THD+N measurement at 60dB below full scale. The measured signal is then corrected by adding the 60dB to it. (e.g. THD+N @ -60dB= -32dB, DR= 92dB).
- 3. THD+N (dB) THD+N is a ratio, of the rms values, of (Noise + Distortion)/Signal.
- 4. Stop band attenuation (dB) Is the degree to which the frequency spectrum is attenuated (outside audio band).
- 5. Channel Separation (dB) Also known as Cross-Talk. This is a measure of the amount one channel is isolated from the other. Normally measured by sending a full scale signal down one channel and measuring the other.



### MASTER CLOCK TIMING

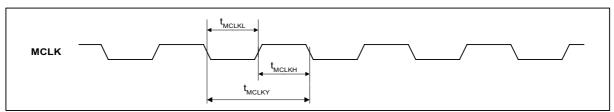


Figure 1 Master Clock Timing Requirements

#### **Test Conditions**

AVDD, DVDD = 5V, AGND = 0V, DGND = 0V,  $T_A$  = +25°C, fs = 48kHz, MCLK = 256fs unless otherwise stated.

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
System Clock Timing Information						
MCLK Master clock pulse width high	t <sub>MCLKH</sub>		13			ns
MCLK Master clock pulse width low	t <sub>MCLKL</sub>		13			ns
MCLK Master clock cycle time	t <sub>MCLKY</sub>		26			ns
MCLK Duty cycle			40:60		60:40	

# DIGITAL AUDIO INTERFACE

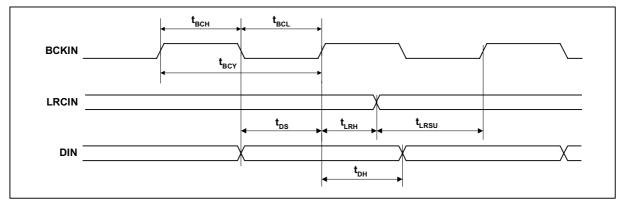


Figure 2 Digital Audio Data Timing

#### **Test Conditions**

AVDD, DVDD = 5V, AGND = 0V, AGND, DGND = 0V,  $T_A = +25^{\circ}C$ , fs = 48kHz, MCLK = 256fs unless otherwise stated.

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Audio Data Input Timing Informatio	n					
BCKIN cycle time	t <sub>BCY</sub>		40			ns
BCKIN pulse width high	t <sub>всн</sub>		16			ns
BCKIN pulse width low	t <sub>BCL</sub>		16			ns
LRCIN set-up time to BCKIN rising edge	t <sub>LRSU</sub>		8			ns
LRCIN hold time from BCKIN rising edge	t <sub>LRH</sub>		8			ns
DIN set-up time to BCKIN rising edge	t <sub>DS</sub>		8			ns
DIN hold time from BCKIN rising edge	t <sub>DH</sub>		8			ns



### **DEVICE DESCRIPTION**

#### INTRODUCTION

The WM8729 is a high performance DAC designed for digital consumer audio applications. Its range of features make it ideally suited for use in DVD players, AV receivers and other high end consumer audio equipment.

The WM8729 is a complete 2-channel stereo audio digital-to-analogue converter, including digital interpolation filter, multi-bit sigma delta with dither, and switched capacitor multi-bit stereo DAC and output smoothing filters. It is fully compatible and an ideal partner for a range of industry standard microprocessors, controllers and DSPs.

Control of internal functionality of the device is provided by hardware control (pin programmed).

Operation using master clocks of 256fs, 384fs, 512fs or 768fs is provided, selection between clock rates being automatically controlled. Sample rates (fs) from less than 8ks/s to 96ks/s are allowed, provided the appropriate system clock is input. Support is also provided for up to 192ks/s using a master clock of 128fs or 192fs.

The audio data interface supports right justified or  $I^2S$  (Philips left justified, one bit delayed) interface formats.

The device is packaged in a small 16-pin SOIC.

### **CLOCKING SCHEMES**

In a typical digital audio system there is only one central clock source producing a reference clock to which all audio data processing is synchronised. This clock is often referred to as the audio system's Master Clock. The external master clock can be applied directly through the MCLK input pin with no configuration necessary for sample rate selection.

Note that on the WM8729, MCLK is used to derive clocks for the DAC path. The DAC path consists of DAC sampling clock, DAC digital filter clock and DAC digital audio interface timing. In a system where there are a number of possible sources for the reference clock it is recommended that the clock source with the lowest jitter be used to optimise the performance of the DAC.

### **DIGITAL AUDIO INTERFACE**

Audio data is applied to the internal DAC filters via the Digital Audio Interface. Two popular interface formats are supported:

- Right Justified mode
- I<sup>2</sup>S mode

Both formats send the MSB first. The WM8729 supports word lengths of 16 or 24 bits in  $I^2S$  mode and 16 or 20 bits in right justified mode. In right justified and  $I^2S$  modes, the digital audio interface receives data on the DIN input. Audio Data is time multiplexed with LRCIN indicating whether the left or right channel is present. LRCIN is also used as a timing reference to indicate the beginning or end of the data words.

In right justified and I<sup>2</sup>S modes, the minimum number of BCKINs per LRCIN period is 2 times the selected word length. LRCIN must be high for a minimum of word length BCKINs and low for a minimum of word length BCKINs. Any mark to space ratio on LRCIN is acceptable provided the above requirements are met.



#### **RIGHT JUSTIFIED MODE**

In right justified mode, the LSB is sampled on the rising edge of BCKIN preceding a LRCIN transition. LRCIN is high during the left samples and low during the right samples.

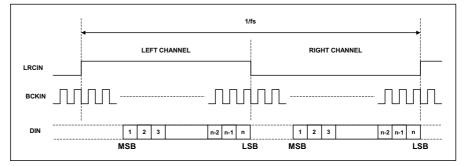


Figure 3 Right Justified Mode Timing Diagram

### I<sup>2</sup>S MODE

In I<sup>2</sup>S mode, the MSB is sampled on the second rising edge of BCKIN following a LRCIN transition. LRCIN is low during the left samples and high during the right samples.

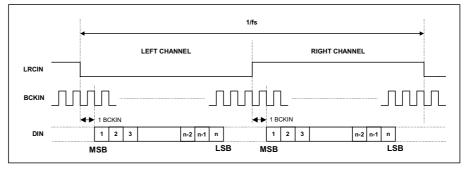


Figure 4 I<sup>2</sup>S Mode Timing Diagram

### AUDIO DATA SAMPLING RATES

The master clock for WM8729 supports audio sampling rates from 128fs to 768fs, where fs is the audio sampling frequency (LRCIN) typically 32kHz, 44.1kHz, 48kHz, 96kHz or 192kHz. The master clock is used to operate the digital filters and the noise shaping circuits.

The WM8729 has a master clock detection circuit that automatically determines the relation between the master clock frequency and the sampling rate (to within +/- 8 master clocks). If there is a greater than 8 clocks error, the interface shuts down the DAC and mutes the output. The master clock should be synchronised with LRCIN, although the WM8729 is tolerant of phase differences or jitter on this clock.

SAMPLING RATE	MASTER CLOCK FREQUENCY (MHZ) (MCLK)						
(LRCIN)	128fs	192fs	256fs	384fs	512fs	768fs	
32kHz	4.096	6.144	8.192	12.288	16.384	24.576	
44.1kHz	5.6448	8.467	11.2896	16.9340	22.5792	33.8688	
48kHz	6.114	9.216	12.288	18.432	24.576	36.864	
96kHz	12.288	18.432	24.576	36.864	Unavailable	Unavailable	
192kHz	24.576	36.864	Unavailable	Unavailable	Unavailable	Unavailable	

Table 1 Master Clock Frequencies Versus Sampling Rate



### HARDWARE CONTROL MODES

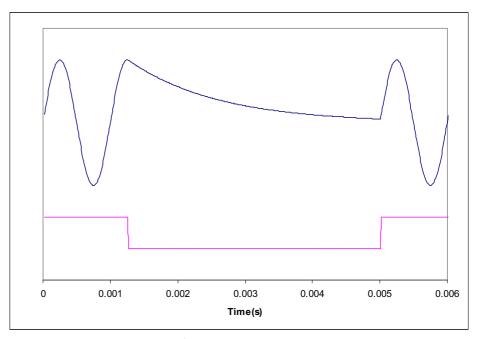
The WM8729 is hardware programmable providing the user with options to select input audio data format, de-emphasis and mute.

### MUTE AND AUTOMUTE OPERATION

Pin 14 (MUTEB) controls selection of MUTE directly, and can be used to enable and disable the automute function, or as an output of the automuted signal.

MUTEB PIN	DESCRIPTION		
0	Mute DAC channels		
1	Normal Operation		
Floating	Enable IZD, MUTEB becomes an output to indicate when IZD occurs.		

 Table 2 Mute and Automute Control



#### Figure 5 Application and Release of MUTEB

The MUTEB pin is an input to select mute or not mute. MUTEB is active low; taking the pin low causes the filters to soft mute, ramping down the audio signal over a few milliseconds. Taking MUTEB high again allows data into the filter. Refer to Figure 5.

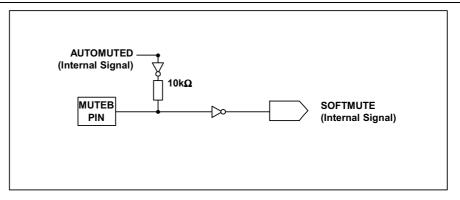
The Infinite Zero Detect (IZD) function detects a series of zero value audio samples of 1024 samples long being applied to both channels. After such an event, a latch is set whose output (AUTOMUTED) is connected through a 10k $\Omega$  resistor to the MUTEB pin. Thus if the MUTEB pin is not being driven, the automute function will assert mute.

If MUTEB is tied high, AUTOMUTED is overridden and will not mute. If MUTEB is driven from a bi-directional source, then both MUTE and automute functions are available. If MUTEB is not driven, AUTOMUTED appears as a weak output (10k source impedance) so can be used to drive external mute circuits. AUTOMUTED will be removed as soon as any channel receives a non-zero input.

A diagram showing how the various Mute modes interact is shown below in Figure 6.



Production Data



#### Figure 6 Selection Logic for MUTE Modes

### INPUT FORMAT SELECTION

FORMAT (pin 16) controls the data input format.

FORMAT	INPUT DATA MODE
0	20-bit right justified (note 2)
1	24-bit I <sup>2</sup> S (note 2)

Table 3 Input Format Selection

#### Notes:

- 1. In 24 bit I<sup>2</sup>S mode, any width of 24 bits or more is supported provided that LRCIN is high for a minimum of 24 BCKINs and low for a minimum of 24 BCKINs, unless Note 2.
- 2. If exactly 16 BCKIN cycles occur in both the low and high period of LRCIN the WM8729 will assume the data is 16 bit and accept the data accordingly.

### **DE-EMPHASIS CONTROL**

DEM (pin 15) is an input control for selection of de-emphasis filtering to be applied.

DEM	DE-EMPHASIS	
0	Off	
1	On	

Table 4 De-emphasis Control

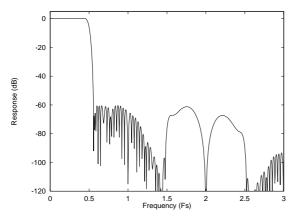


## **DIGITAL FILTER CHARACTERISTICS**

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Passband Edge		-3dB		0.487fs		
Passband Ripple		f < 0.444fs			±0.05	dB
Stopband Attenuation		f > 0.555fs	-60			dB

# Table 5 Digital Filter Characteristics

### DAC FILTER RESPONSES





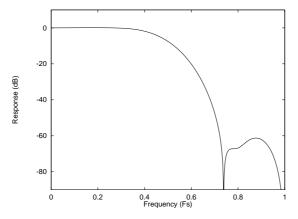


Figure 9 DAC Digital Filter Frequency Response -192kHz

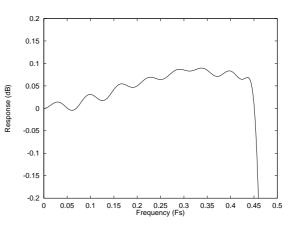


Figure 8 DAC Digital Filter Ripple -44.1, 48 and 96kHz

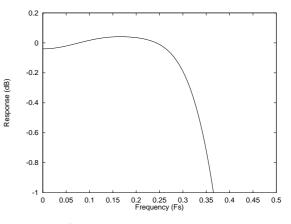


Figure 10 DAC Digital Filter Ripple -192kHz



# **DIGITAL DE-EMPHASIS CHARACTERISTICS**

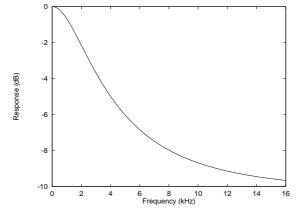


Figure 11 De-Emphasis Frequency Response (32kHz)

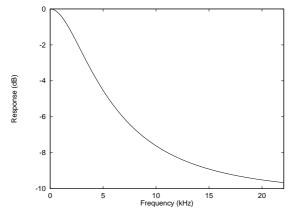


Figure 13 De-Emphasis Frequency Response (44.1kHz)

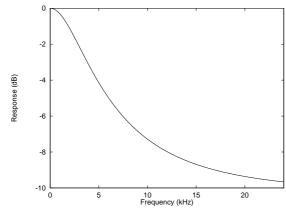


Figure 15 De-Emphasis Frequency Response (48kHz)

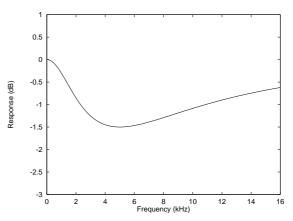


Figure 12 De-Emphasis Error (32kHz)

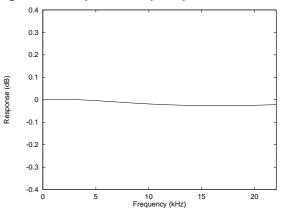


Figure 14 De-Emphasis Error (44.1kHz)

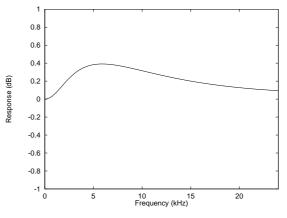


Figure 16 De-Emphasis Error (48kHz)



## **APPLICATIONS INFORMATION**

## **RECOMMENDED EXTERNAL COMPONENTS**

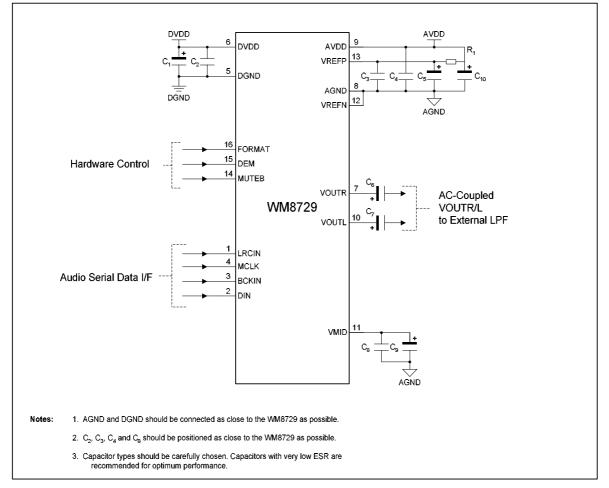


Figure 17 External Component Diagram

### **RECOMMENDED EXTERNAL COMPONENTS VALUES**

COMPONENT REFERENCE	SUGGESTED VALUE	DESCRIPTION	
C1 and C5	10µF	De-coupling for DVDD and AVDD/VREFP	
C2 to C4	0.1µF	De-coupling for DVDD and AVDD/VREFP	
C6 and C7	10µF	Output AC coupling caps to remove midrail DC level from outputs	
C8	0.1µF	Reference de-coupling capacitors for VMID pin.	
C9	10μF		
C10	10µF	Filtering for VREFP. Omit if AVDD low noise.	
R1	33Ω	Filtering for VREP. Use $0\Omega$ if AVDD low noise.	

Table 6 External Components Description



# **RECOMMENDED ANALOGUE LOW PASS FILTER (OPTIONAL)**

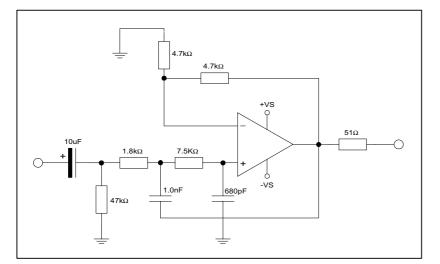
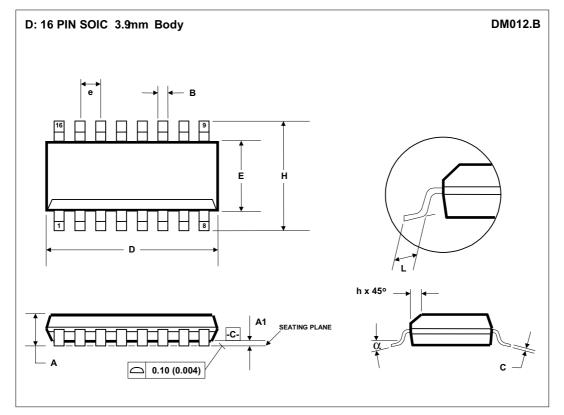


Figure 18 Recommended Low Pass Filter (Optional)



## **PACKAGE DRAWING**



Symbols	Dimensions (mm)		Dimensions (Inches)		
	MIN	MAX	MIN	MAX	
Α	1.35	1.75	0.0532	0.0688	
A1	0.10	0.25	0.0040	0.0098	
В	0.33	0.51	0.0130	0.0200	
С	0.19	0.25	0.0075	0.0098	
D	9.80	10.00	0.3859	0.3937	
E	3.80	4.00	0.1497	0.1574	
е	1.27 BSC		0.05 BSC		
Н	5.80	6.20	0.2284	0.2440	
h	0.25	0.50	0.0099	0.0196	
L	0.40	1.27	0.0160	0.0500	
α	0°	8°	0°	8°	
REF:	JEDEC.95, MS-012				

NOTES: A. ALL LINEAR DIMENSIONS ARE IN MILLIMETERS (INCHES). B. THIS DRAWING IS SUBJECT TO CHANGE WITHOUT NOTICE. C. BODY DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSION, NOT TO EXCEED 0.25MM (0.010IN). D. MEETS JEDEC.95 MS-012, VARIATION = AC. REFER TO THIS SPECIFICATION FOR FURTHER DETAILS.

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