

24-bit, 192kHz 6-Channel DAC

DESCRIPTION

The WM8763/4/5 are multi-channel audio DACs ideal for DVD and surround sound processing applications for home hi-fi, automotive and other audio visual equipment.

Three stereo 24-bit multi-bit sigma delta DACs are used with oversampling digital interpolation filters. Digital audio input word lengths from 16-32 bits and sampling rates from 8kHz to 192kHz are supported.

The audio data interface supports either 16-24-bit I²S, 16-24-bit left justified, or 24-bit right justified digital audio formats.

The devices are controlled directly using the hardware interface. All members of the family are available in a 20-pin SSOP.

FEATURES

- 6-Channel DAC with PCM.
- Audio Performance
 - 103dB SNR ('A' weighted @ 48kHz) DAC
- DAC Sampling Frequency: 8kHz – 192kHz
- Hardware Control Interface
- Choice of Audio Data Interface Modes
 - WM8763: 16-24-bit I²S
 - WM8764: 16-24-bit Left Justified
 - WM8765: 16-24-bit Right Justified
- Slave Audio Data Interface
- 2.7V to 5.5V Analogue, 2.7V to 3.6V Digital supply Operation
- 20 pin SSOP Package

APPLICATIONS

- DVD Players
- Surround Sound AV Processors and Hi-Fi systems
- Automotive Audio

BLOCK DIAGRAM

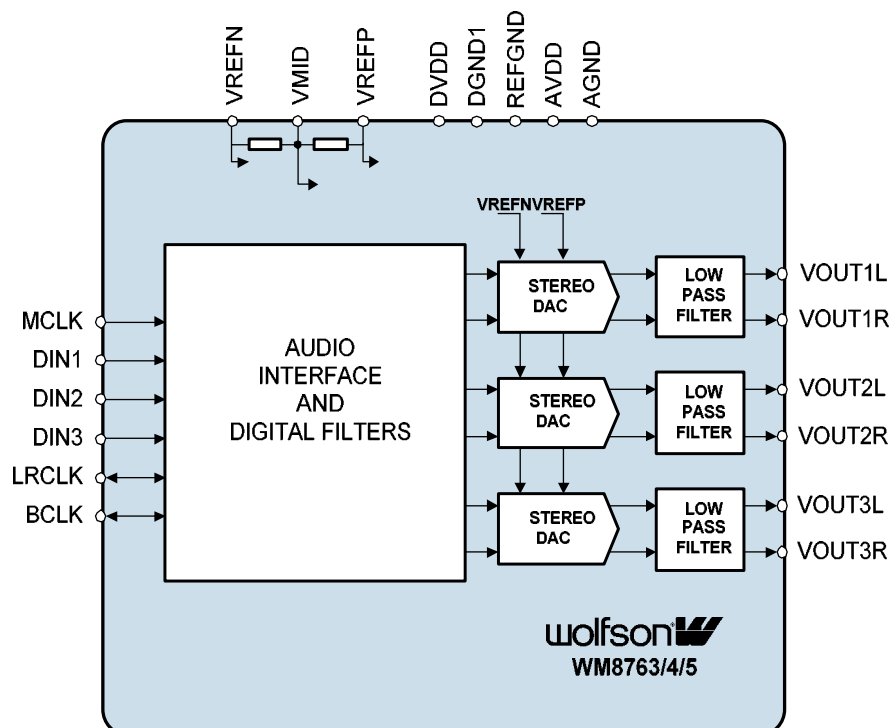
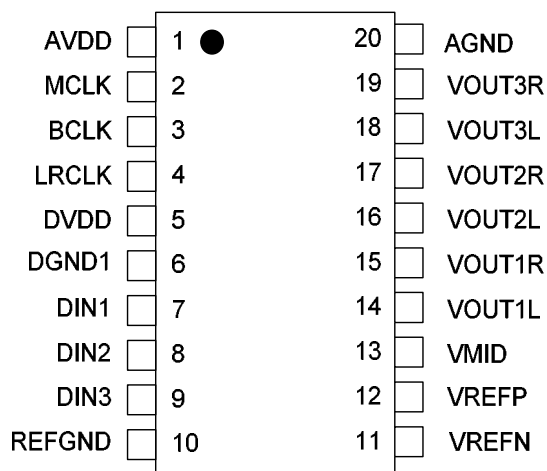


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PIN CONFIGURATION 20 LEAD SSOP



ORDERING INFORMATION

DEVICE	TEMP. RANGE	PACKAGE	MOISTURE SENSITIVITY LEVEL
WM8763EDS	-25 to +85°C	20-pin SSOP	MSL1
WM8763GEDS	-25 to +85°C	20-pin SSOP (lead free)	MSL1
WM8763EDS/R	-25 to +85°C	20-pin SSOP (tape and reel)	MSL1
WM8763GEDS/R	-25 to +85°C	20-pin SSOP (lead free, tape and reel)	MSL1

DEVICE	TEMP. RANGE	PACKAGE	MOISTURE SENSITIVITY LEVEL
WM8764EDS	-25 to +85°C	20-pin SSOP	MSL1
WM8764GEDS	-25 to +85°C	20-pin SSOP (lead free)	MSL1
WM8764EDS/R	-25 to +85°C	20-pin SSOP (tape and reel)	MSL1
WM8764GEDS/R	-25 to +85°C	20-pin SSOP (lead free, tape and reel)	MSL1

DEVICE	TEMP. RANGE	PACKAGE	MOISTURE SENSITIVITY LEVEL
WM8765EDS	-25 to +85°C	20-pin SSOP	MSL1
WM8765GEDS	-25 to +85°C	20-pin SSOP (lead free)	MSL1
WM8765EDS/R	-25 to +85°C	20-pin SSOP (tape and reel)	MSL1
WM8765GEDS/R	-25 to +85°C	20-pin SSOP (lead free, tape and reel)	MSL1

Note:

Reel quantity = 2,000

PIN DESCRIPTION – 20 PIN SSOP

PIN	NAME	TYPE	DESCRIPTION
1	AVDD	Supply	Analogue positive supply
2	MCLK	Digital input	Master clock; 128, 192, 256, 384, 512 or 768fs (fs = word clock frequency)
3	BCLK	Digital input	Audio interface bit clock
4	LRCLK	Digital input	Audio left/right word clock
5	DVDD	Digital supply	Digital positive supply
6	DGND1	Digital ground	Digital Negative supply 1
7	DIN1	Digital input	DAC channel 1 data input
8	DIN2	Digital input	DAC channel 2 data input
9	DIN3	Digital input	DAC channel 3 data input
10	REFGND	Digital input	Ground Reference
11	VREFN	Analogue Input	DAC negative reference supply
12	VREFP	Analogue Input	DAC positive reference supply
13	VMID	Analogue output	Midrail divider decoupling pin; 10uF external decoupling
14	VOUT1L	Analogue output	DAC channel 1 left output
15	VOUT1R	Analogue output	DAC channel 1 right output
16	VOUT2L	Analogue output	DAC channel 2 left output
17	VOUT2R	Analogue output	DAC channel 2 right output
18	VOUT3L	Analogue output	DAC channel 3 left output
19	VOUT3R	Analogue output	DAC channel 3 right output
20	AGND	Supply	Analogue negative and substrate connection

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:

MSL1 = unlimited floor life at <30°C / 85% Relative Humidity. Not normally stored in moisture barrier bag.

MSL2 = out of bag storage for 1 year at <30°C / 60% Relative Humidity. Supplied in moisture barrier bag.

MSL3 = out of bag storage for 168 hours at <30°C / 60% Relative Humidity. Supplied in moisture barrier bag.

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

CONDITION	MIN	MAX
Digital supply voltage	-0.3V	+5V
Analogue supply voltage	-0.3V	+7V
Voltage range digital inputs	AGND -0.3V	DVDD +0.3V
Voltage range analogue inputs	AGND -0.3V	AVDD +0.3V
Master Clock Frequency		37MHz
Operating temperature range, T _A	-25°C	+85°C
Storage temperature after soldering	-65°C	+150°C
Package body temperature (soldering 10 seconds)		+240°C
Package body temperature (soldering 2 minutes)		+183°C

Notes:

1. Analogue and digital grounds must always be within 0.3V of each other for normal operation of the device.

RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Digital supply range	DVDD		2.7		3.6	V
Analogue supply range	AVDD, VREFP		2.7		5.5	V
Ground	GND, VREFN			0		V

Note: Digital supply DVDD must never be more than 0.3V greater than AVDD for normal operation of the device.

ELECTRICAL CHARACTERISTICS

Test Conditions

AVDD, VREFP = 5V, DVDD = 3.3V, GND, VREFN = 0V, T_A = +25°C, f_s = 48kHz, MCLK = 256fs, unless otherwise stated.

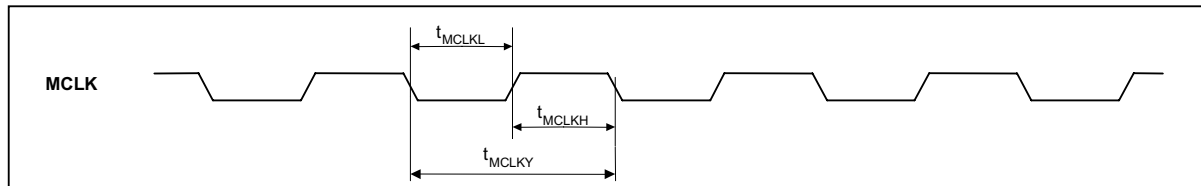
PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Digital Logic Levels (CMOS Levels)						
Input LOW level	V _{IL}				0.3 x DVDD	V
Input HIGH level	V _{IH}		0.7 x DVDD			V
Output LOW	V _{OL}	I _{OL} =1mA			0.1 x DVDD	V
Output HIGH	V _{OH}	I _{OH} = -1mA	0.9 x DVDD			V
Analogue Reference Levels						
Reference voltage	V _{VMID}			VREFP/2		V
Potential divider resistance	R _{VMID}			100k		Ω
DAC Performance (Load = 10kΩ, 50pF)						
0dBfs Full scale output voltage				1.0 x VREFP/5		V _{rms}
SNR (Note 1,2,4)		A-weighted, @ f _s = 48kHz	95	103		dB
SNR (Note 1,2,4)		A-weighted @ f _s = 96kHz		101		dB
SNR (Note 1,2,4)		A-weighted @ f _s = 192kHz		101		dB
SNR (Note 1,2,4)		A-weighted @ f _s = 48kHz, AVDD = 3.3V		101		dB
SNR (Note 1,2,4)		A-weighted @ f _s = 96kHz, AVDD = 3.3V		96		dB
Dynamic Range (Note 2,4)	DNR	A-weighted, -60dB full scale input	95	103		dB
Total Harmonic Distortion (THD) (Note 4)		1kHz, 0dBfs		-90	-85	dB
Mute Attenuation		1kHz Input, 0dB gain		100		dB
DAC channel separation				100		dB
Power Supply Rejection Ratio	PSRR	1kHz 100mVpp		50		dB
		20Hz to 20kHz 100mVp-p		45		dB
Supply Current						
Analogue supply current		AVDD = 5V		13.8		mA
Digital Supply Current		DVDD = 3.3V		11		mA

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.
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).
4. The performance of each DAC is measured separately

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).
2. 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.
6. Pass-Band Ripple - Any variation of the frequency response in the pass-band region.

MASTER CLOCK TIMING**Figure 1 DAC Master Clock Timing Requirements****Test Conditions**

AVDD, VREFP = 5V, DVDD = 3.3V, GND, VREFN = 0V, $T_A = +25^\circ\text{C}$, $f_s = 48\text{kHz}$, DACMCLK and ADCMCLK = 256fs unless otherwise stated.

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
System Clock Timing Information						
MCLK System clock pulse width high	t_{MCLKH}		11			ns
MCLK System clock pulse width low	t_{MCLKL}		11			ns
MCLK System clock cycle time	t_{MCLKY}		28			ns
MCLK Duty cycle			40:60		60:40	

Table 1 Master Clock Timing Requirements

DIGITAL AUDIO INTERFACE

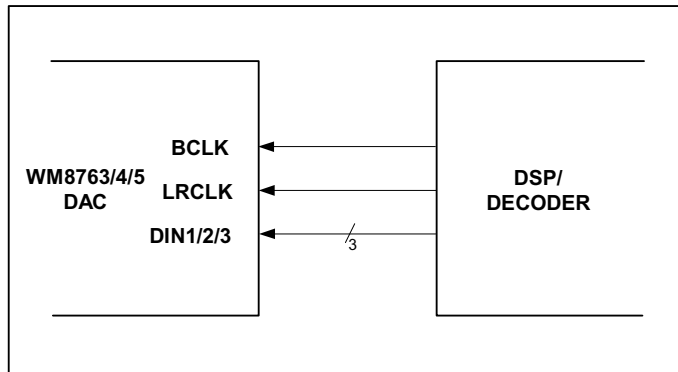


Figure 2 Audio Interface

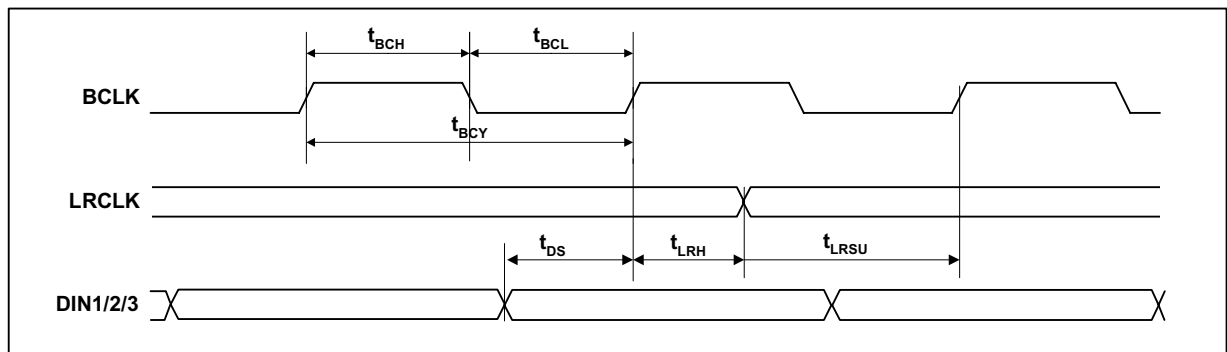


Figure 3 Digital Audio Data Timing – Slave Mode

Test Conditions

AVDD = 5V, DVDD = 3.3V, AGND = 0V, DGND = 0V, T_A = +25°C, fs = 48kHz, MCLK = 256fs unless otherwise stated.

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Audio Data Input Timing Information						
BCLK cycle time	t _{BCY}		50			ns
BCLK pulse width high	t _{BCH}		20			ns
BCLK pulse width low	t _{BCL}		20			ns
LRCLK set-up time to BCLK rising edge	t _{LRSU}		10			ns
LRCLK hold time from BCLK rising edge	t _{LRH}		10			ns
DIN1/2/3 set-up time to BCLK rising edge	t _{DS}		10			ns
DIN1/2/3 hold time from BCLK rising edge	t _{DH}		10			ns

Table 2 Digital Audio Data Timing – Slave Mode

DEVICE DESCRIPTION

INTRODUCTION

WM8763/4/5 is a complete 6-channel DAC including digital interpolation and decimation filters and switched capacitor multi-bit sigma delta DACs with digital volume controls on each channel and output smoothing filters.

The device is implemented as 3 separate stereo DACs in a single package and controlled by a single interface.

Each stereo DAC has its own data input DIN1/2/3. DAC word clock LRCLK and DAC bit clock BCLK and DAC master clock MCLK are shared between them.

Operation using master clocks of 128fs, 192fs, 256fs, 384fs, 512fs or 768fs is provided for the DAC. The selection between clock rates is automatically controlled. Audio sample rates (fs) from less than 8ks/s up to 192ks/s are allowed for the DAC, provided the appropriate master clock is input.

The audio data interface supports right, left and I²S interface formats.

AUDIO DATA SAMPLING RATES

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 system clock can be applied directly through the MCLK input pin(s) with no software configuration necessary.

The DAC master clock for WM8763/4/5 supports audio sampling rates from 128fs to 768fs, where fs is the audio sampling frequency (LRCLK) typically 32kHz, 44.1kHz, 48kHz, 96kHz or 192kHz. The master clock is used to operate the digital filters and the noise shaping circuits.

In Slave mode the WM8763/4/5 has a master clock detection circuit that automatically determines the relationship between the system clock frequency and the sampling rate (to within +/- 32 master clocks). If there is a greater than 32 clocks error the interface defaults to 768fs mode. The WM8763/4/5 is tolerant of phase variations or jitter on the master clock. Table 3 shows the typical master clock frequency inputs for the WM8763/4/5.

The signal processing for the WM8763/4/5 typically operates at an oversampling rate of 128fs. The exception to this is for operation with a 128/192fs system clock, e.g. for 192kHz operation, when the oversampling rate is 64fs.

SAMPLING RATE (LRCLK)	System Clock Frequency (MHz)					
	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	6.144	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 3 System Clock Frequencies Versus Sampling Rate

DIGITAL AUDIO INTERFACE

SLAVE MODE

The audio interface operates in Slave mode. The default is Slave mode.

In Slave mode, LRCLK and BCLK are inputs to the WM8763/4/5 (Figure 4). DIN1/2/3 and LRCLK are sampled by the WM8763/4/5 on the rising edge of BCLK.

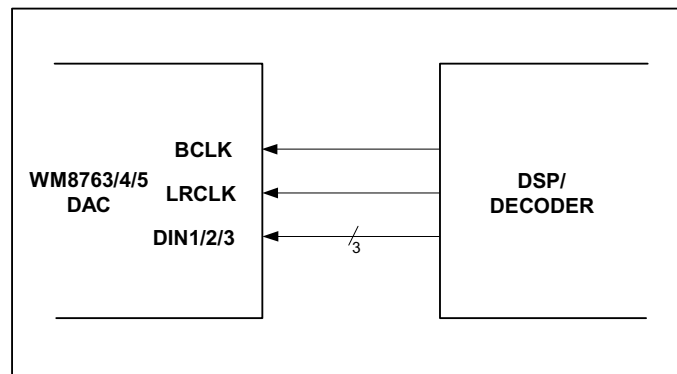


Figure 4 Slave Mode

AUDIO INTERFACE FORMATS

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

- Left Justified mode
- Right Justified mode
- I²S mode

All 3 formats send the MSB first and support word lengths of 16, 20, and 24.

In left justified, right justified and I²S modes, the digital audio interface receives DAC data on the DIN1/2/3 inputs. Audio Data for each stereo channel is time multiplexed with LRCLK indicating whether the left or right channel is present. LRCLK is also used as a timing reference to indicate the beginning or end of the data words.

In left justified, right justified and I²S modes, the minimum number of BCLKs per LRCLK period is 2 times the selected word length. LRCLK must be high for a minimum of word length BCLKs and low for a minimum of word length BCLKs. Any mark to space ratio on LRCLK is acceptable provided the above requirements are met. If exactly 32 bit clocks occur in one left/right clock (16 high, 16 low) the chip will auto detect and run at 16 bit data mode.

LEFT JUSTIFIED MODE (WM8764 ONLY)

In left justified mode, the MSB of DIN1/2/3 is sampled by the WM8764 on the first rising edge of BCLK following a LRCLK transition. LRCLK is high during the left samples and low during the right samples (Figure 5).

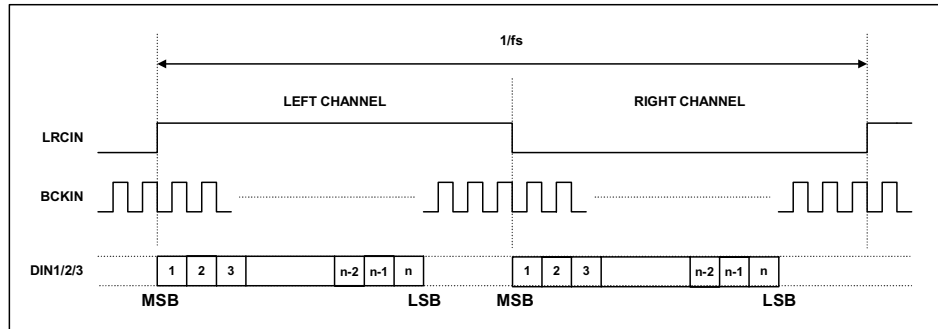


Figure 5 Left Justified Mode Timing Diagram

RIGHT JUSTIFIED MODE (WM8765 ONLY)

In right justified mode, the LSB of DIN1/2/3 is sampled by the WM8765 on the rising edge of BCLK preceding a LRCLK transition. LRCLK are high during the left samples and low during the right samples (Figure 6).

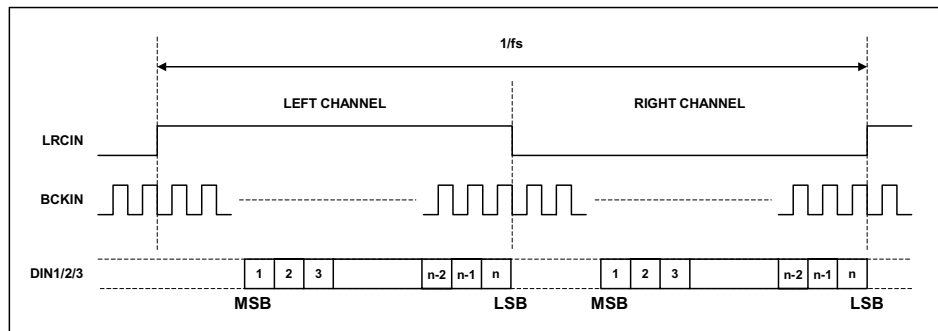


Figure 6 Right Justified Mode Timing Diagram

I²S MODE (WM8763 ONLY)

In I²S mode, the MSB of DIN1/2/3 is sampled by the WM8763 on the second rising edge of BCLK following a LRCLK transition. LRCLK are low during the left samples and high during the right samples.

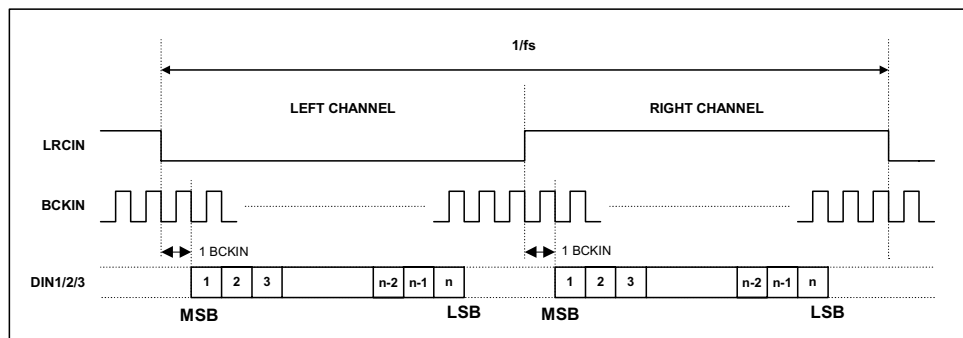


Figure 7 I²S Mode Timing Diagram

DIGITAL FILTER CHARACTERISTICS

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Passband	± 0.05 dB			0.444fs	
	-3dB		0.487fs		
Passband ripple				± 0.05	dB
Stopband		0.555fs			
Stopband Attenuation	$f > 0.555fs$	-60			dB
Group Delay			21		fs

Table 11 Digital Filter Characteristics

DAC FILTER RESPONSES

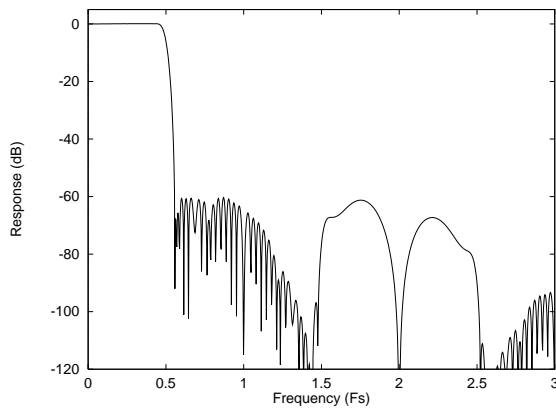


Figure 8 DAC Digital Filter Frequency Response – 44.1, 48 and 96kHz

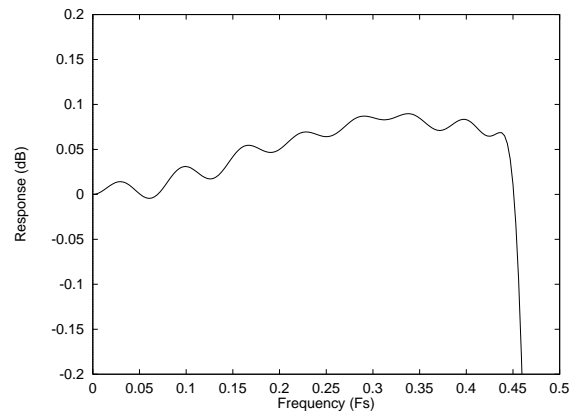


Figure 9 DAC Digital Filter Ripple –44.1, 48 and 96kHz

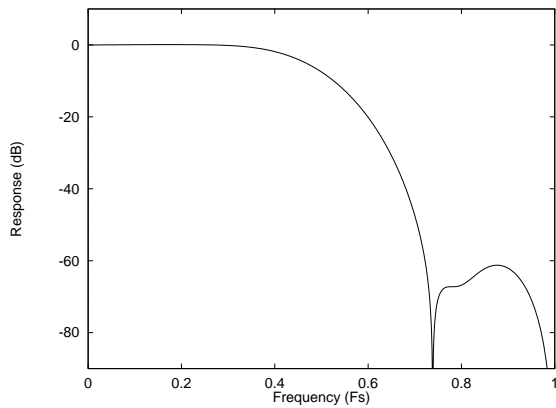


Figure 10 DAC Digital Filter Frequency Response – 192kHz

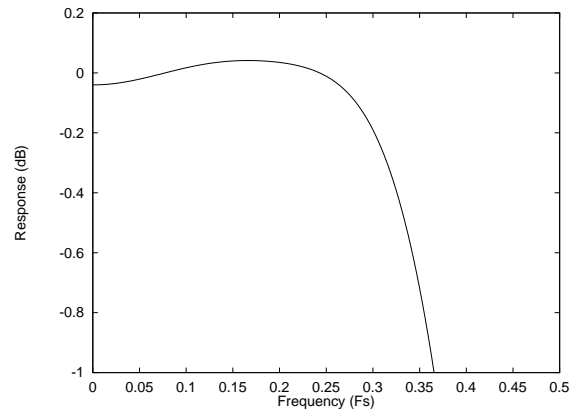


Figure 11 DAC Digital filter Ripple – 192kHz

DIGITAL DE-EMPHASIS CHARACTERISTICS

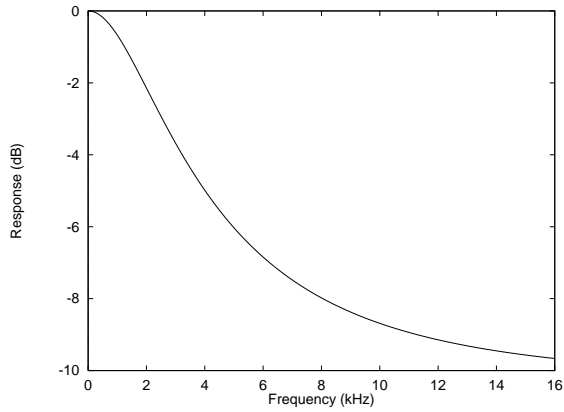


Figure 12 De-Emphasis Frequency Response (32kHz)

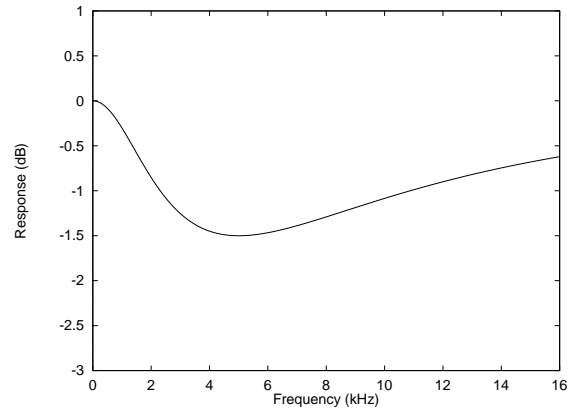


Figure 13 De-Emphasis Error (32kHz)

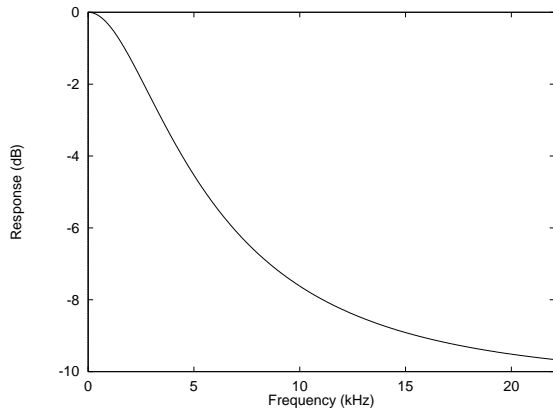


Figure 14 De-Emphasis Frequency Response (44.1kHz)

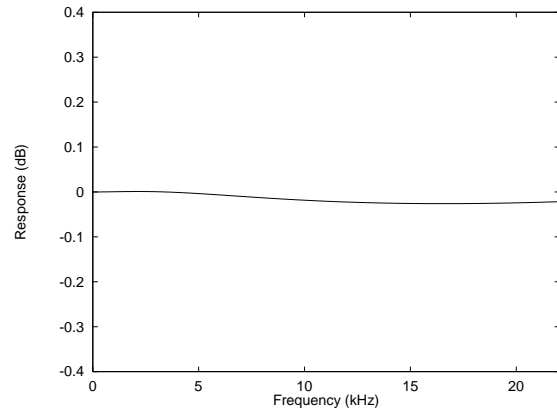


Figure 15 De-Emphasis Error (44.1kHz)

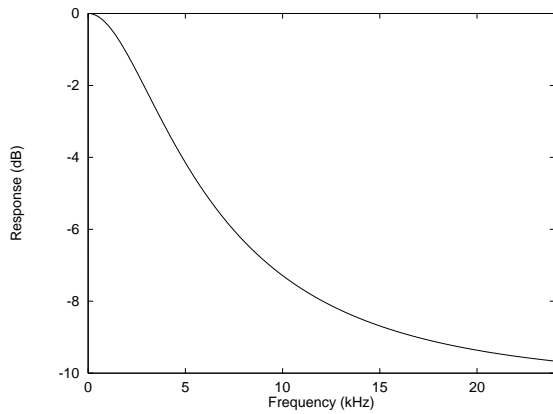


Figure 16 De-Emphasis Frequency Response (48kHz)

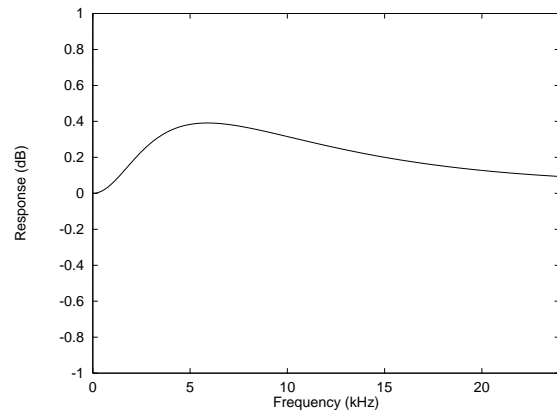


Figure 17 De-Emphasis Error (48kHz)

APPLICATIONS INFORMATION

RECOMMENDED EXTERNAL COMPONENTS

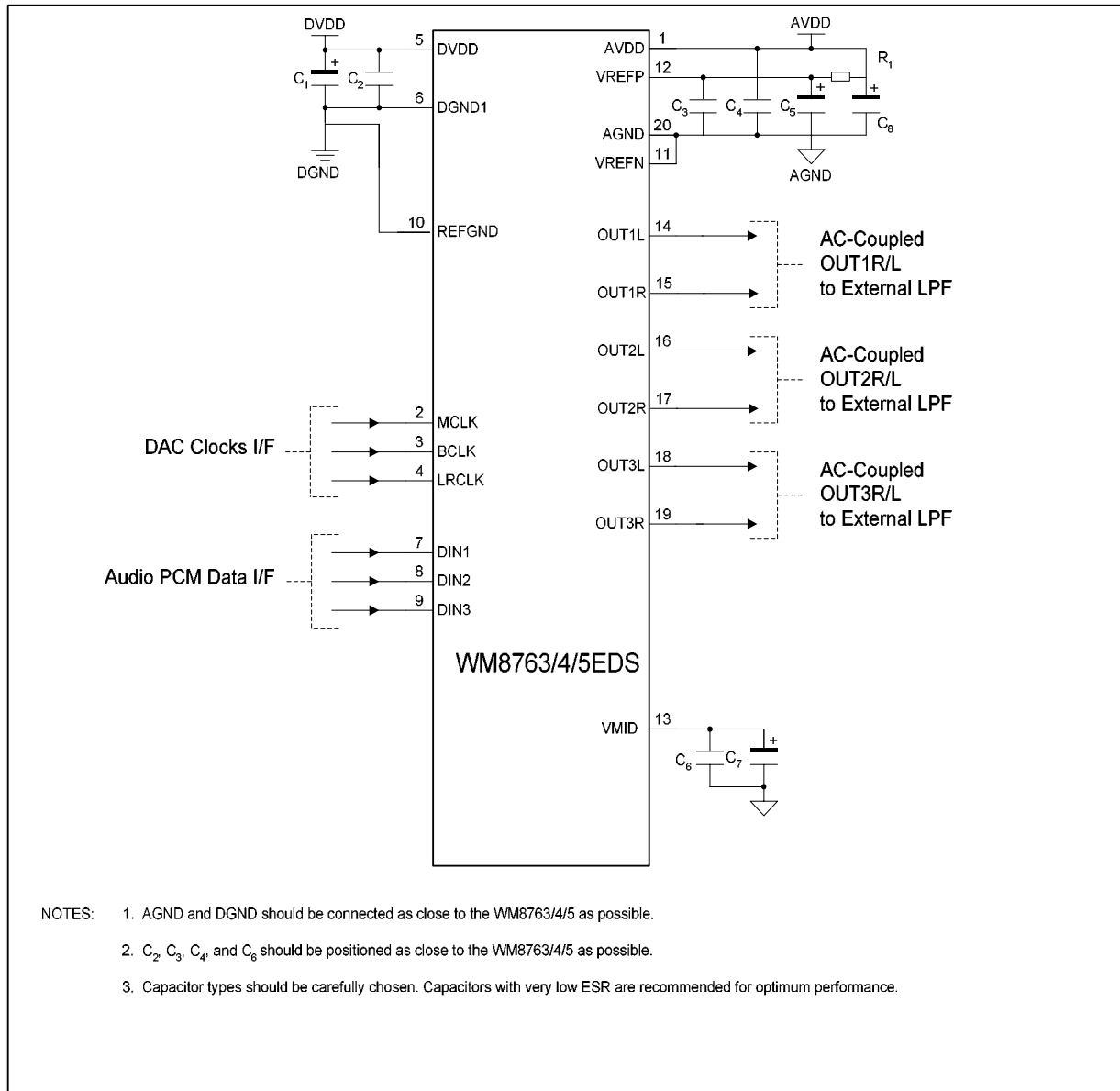


Figure 18 Recommended External Components Diagram

RECOMMENDED EXTERNAL COMPONENTS VALUES

COMPONENT REFERENCE	SUGGESTED VALUE	DESCRIPTION
C1 and C5	10µF	De-coupling for DVDD and AVDD.
C2 to C4	0.1µF	De-coupling for DVDD and AVDD.
C6	0.1µF	Reference de-coupling capacitors for VMID.
C7	10µF	
C8	10µF	Filtering for VREFP. Omit if AVDD low noise.
R1	33VΩ	Filtering for VREFP. Use 0Ω if AVDD low noise.

Table 4 External Components Description

SUGGESTED ANALOGUE LOW PASS POST DAC FILTERS

It is recommended that a lowpass filter be applied to the output from each DAC channel for Hi Fi applications. Typically a second order filter is suitable and provides sufficient attenuation of high frequency components (the unique low order, high bit count multi-bit sigma delta DAC structure used in WM8763/4/5 produces much less high frequency output noise than normal sigma delta DACs. This filter is typically also used to provide the 2x gain needed to provide the standard 2Vrms output level from most consumer equipment. Figure 19 shows a suitable post DAC filter circuit, with 2x gain. Alternative inverting filter architectures might also be used with as good results.

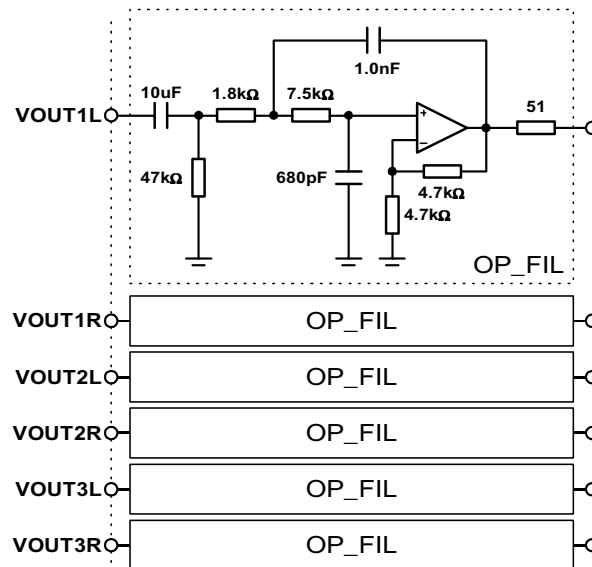
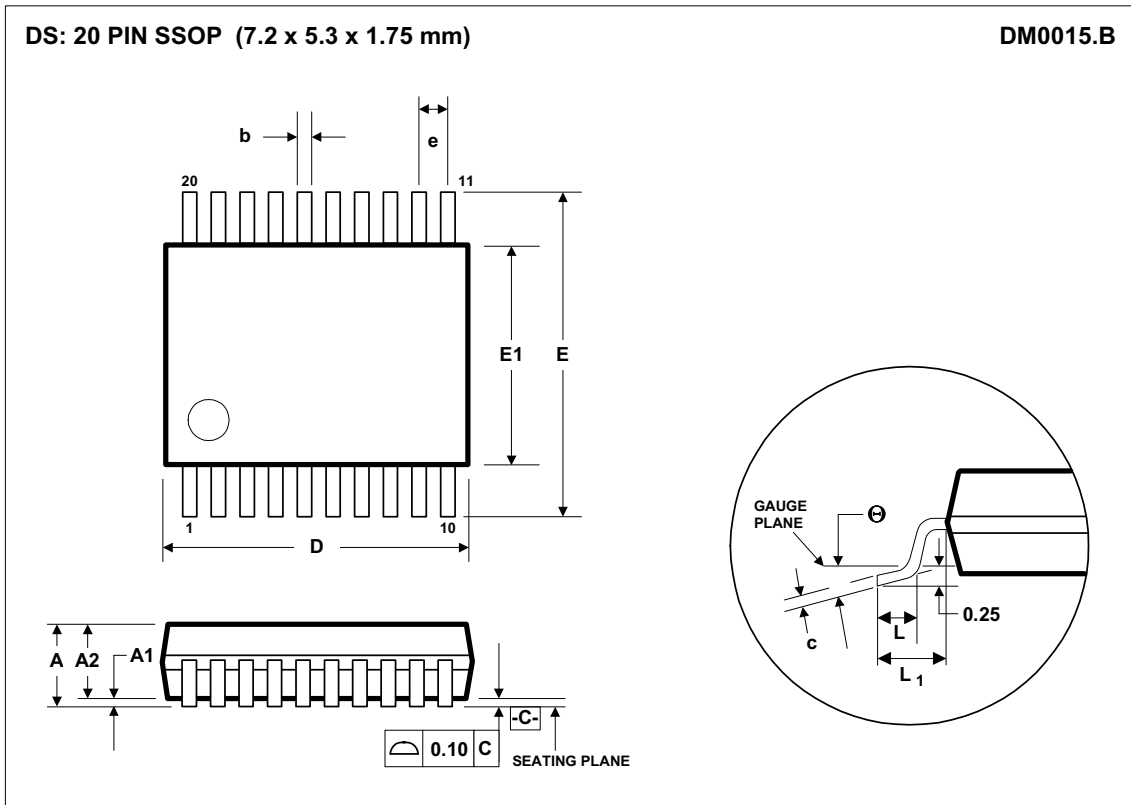


Figure 19 Recommended Post DAC Filter Circuit

PACKAGE DRAWING



Symbols	Dimensions (mm)		
	MIN	NOM	MAX
A	-----	-----	2.0
A ₁	0.05	-----	-----
A ₂	1.65	1.75	1.85
b	0.22	0.30	0.38
c	0.09	-----	0.25
D	6.90	7.20	7.50
e	0.65 BSC		
E	7.40	7.80	8.20
E ₁	5.00	5.30	5.60
L	0.55	0.75	0.95
L ₁	0.125 REF		
θ	0°	4°	8°
REF:	JEDEC.95, MO-150		

- NOTES:
 A. ALL LINEAR DIMENSIONS ARE IN MILLIMETERS.
 B. THIS DRAWING IS SUBJECT TO CHANGE WITHOUT NOTICE.
 C. BODY DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSION, NOT TO EXCEED 0.20MM.
 D. MEETS JEDEC.95 MO-150, VARIATION = AE. REFER TO THIS SPECIFICATION FOR FURTHER DETAILS.

IMPORTANT NOTICE

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