



## 24-BIT, 192-kHz SAMPLING, ADVANCED SEGMENT, AUDIO STEREO DIGITAL-TO-ANALOG CONVERTER

### FEATURES

- 24-Bit Resolution
- Analog Performance:
  - Dynamic Range: 132 dB (9 V RMS, Mono)  
129 dB (4.5 V RMS, Stereo)  
127 dB (2 V RMS, Stereo)
  - THD+N: 0.0004%
- Differential Current Output: 7.8 mA p-p
- 8× Oversampling Digital Filter:
  - Stop-Band Attenuation: –130 dB
  - Pass-Band Ripple:  $\pm 0.00001$  dB
- Sampling Frequency: 10 kHz to 200 kHz
- System Clock: 128, 192, 256, 384, 512, or 768  $f_s$  With Autodetect
- Accepts 16- and 24-Bit Audio Data
- PCM Data Formats: Standard,  $I^2S$ , and Left-Justified
- Optional Interface Available to External Digital Filter or DSP
- Digital De-Emphasis
- Digital Filter Rolloff: Sharp or Slow
- Soft Mute
- Zero Flag

- Dual-Supply Operation:
  - 5-V Analog, 3.3-V Digital
- 5-V Tolerant Digital Inputs
- Small 28-Lead SSOP Package

### APPLICATIONS

- A/V Receivers
- DVD Players
- Musical Instruments
- HDTV Receivers
- Car Audio Systems
- Digital Multitrack Recorders
- Other Applications Requiring 24-Bit Audio

### DESCRIPTION

The PCM1794 is a monolithic CMOS integrated circuit that includes stereo digital-to-analog converters and support circuitry in a small 28-lead SSOP package. The data converters use TI's advanced segment DAC architecture to achieve excellent dynamic performance and improved tolerance to clock jitter. The PCM1794 provides balanced current outputs, allowing the user to optimize analog performance externally. Sampling rates up to 200 kHz are supported.



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

## ORDERING INFORMATION

PRODUCT	PACKAGE	PACKAGE CODE	OPERATION TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA
PCM1794DB	28-lead SSOP	28DB	–25°C to 85°C	PCM1794	PCM1794DB	Tube
					PCM1794DBR	Tape and reel

## ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range unless otherwise noted<sup>(1)</sup>

		PCM1794
Supply voltage	V <sub>CC1</sub> , V <sub>CC2L</sub> , V <sub>CC2R</sub>	–0.3 V to 6.5 V
	V <sub>DD</sub>	–0.3 V to 4 V
Supply voltage differences: V <sub>CC1</sub> , V <sub>CC2L</sub> , V <sub>CC2R</sub>		±0.1 V
Ground voltage differences: AGND1, AGND2, AGND3L, AGND3R, DGND		±0.1 V
Digital input voltage	LRCK, DATA, BCK, SCK, FMT1, FMT0, MONO, CHSL, DEM, MUTE, RST,	–0.3 V to 6.5 V
	ZERO	–0.3 V to (V <sub>DD</sub> + 0.3 V) < 4 V
Analog input voltage		–0.3 V to (V <sub>CC</sub> + 0.3 V) < 6.5 V
Input current (any pins except supplies)		±10 mA
Ambient temperature under bias		–40°C to 125°C
Storage temperature		–55°C to 150°C
Junction temperature		150°C
Lead temperature (soldering)		260°C, 5 s
Package temperature (IR reflow, peak)		250°C

(1) Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

all specifications at T<sub>A</sub> = 25°C, V<sub>CC1</sub> = V<sub>CC2L</sub> = V<sub>CC2R</sub> = 5 V, V<sub>DD</sub> = 3.3 V, f<sub>S</sub> = 44.1 kHz, system clock = 256 f<sub>S</sub>, and 24-bit data, unless otherwise noted

PARAMETER		TEST CONDITIONS	PCM1794DB			UNIT
			MIN	TYP	MAX	
RESOLUTION			24			Bits
DATA FORMAT						
Audio data interface format			Standard, I <sup>2</sup> S, left justified			
Audio data bit length			16-, 24-bit selectable			
Audio data format			MSB first, 2s complement			
f <sub>S</sub>	Sampling frequency		10	200		kHz
System clock frequency			128, 192, 256, 384, 512, 768 f <sub>S</sub>			
DIGITAL INPUT/OUTPUT						
Logic family			TTL compatible			
V <sub>IH</sub>	Input logic level		2			VDC
V <sub>IL</sub>			0.8			
I <sub>IH</sub>	Input logic current	V <sub>IN</sub> = V <sub>DD</sub>	10			μA
I <sub>IL</sub>		V <sub>IN</sub> = 0 V	−10			
V <sub>OH</sub>	Output logic level	I <sub>OH</sub> = −2 mA	2.4			VDC
V <sub>OL</sub>		I <sub>OI</sub> = 2 mA	0.4			

## ELECTRICAL CHARACTERISTICS (Continued)

all specifications at  $T_A = 25^\circ\text{C}$ ,  $V_{CC1} = V_{CC2L} = V_{CC2R} = 5\text{ V}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $f_S = 44.1\text{ kHz}$ , system clock =  $256 f_S$ , and 24-bit data, unless otherwise noted

PARAMETER	TEST CONDITIONS	PCM1794DB			UNIT
		MIN	TYP	MAX	
DYNAMIC PERFORMANCE (2-V RMS OUTPUT) (1)(2)					
THD+N at V <sub>OUT</sub> = 0 dB	f <sub>S</sub> = 44.1 kHz		0.0004%	0.0008%	
	f <sub>S</sub> = 96 kHz		0.0008%		
	f <sub>S</sub> = 192 kHz		0.0015%		
Dynamic range	EIAJ, A-weighted, f <sub>S</sub> = 44.1 kHz	123	127		dB
	EIAJ, A-weighted, f <sub>S</sub> = 96 kHz		127		
	EIAJ, A-weighted, f <sub>S</sub> = 192 kHz		127		
Signal-to-noise ratio	EIAJ, A-weighted, f <sub>S</sub> = 44.1 kHz	123	127		dB
	EIAJ, A-weighted, f <sub>S</sub> = 96 kHz		127		
	EIAJ, A-weighted, f <sub>S</sub> = 192 kHz		127		
Channel separation	f <sub>S</sub> = 44.1 kHz	120	123		dB
	f <sub>S</sub> = 96 kHz		122		
	f <sub>S</sub> = 192 kHz		120		
Level linearity error	V <sub>OUT</sub> = −120 dB		±1		dB
DYNAMIC PERFORMANCE (4.5-V RMS Output) (1)(3)					
THD+N at V <sub>OUT</sub> = 0 dB	f <sub>S</sub> = 44.1 kHz		0.0004%		
	f <sub>S</sub> = 96 kHz		0.0008%		
	f <sub>S</sub> = 192 kHz		0.0015%		
Dynamic range	EIAJ, A-weighted, f <sub>S</sub> = 44.1 kHz		129		dB
	EIAJ, A-weighted, f <sub>S</sub> = 96 kHz		129		
	EIAJ, A-weighted, f <sub>S</sub> = 192 kHz		129		
Signal-to-noise ratio	EIAJ, A-weighted, f <sub>S</sub> = 44.1 kHz		129		dB
	EIAJ, A-weighted, f <sub>S</sub> = 96 kHz		129		
	EIAJ, A-weighted, f <sub>S</sub> = 192 kHz		129		
Channel separation	f <sub>S</sub> = 44.1 kHz		124		dB
	f <sub>S</sub> = 96 kHz		123		
	f <sub>S</sub> = 192 kHz		121		
DYNAMIC PERFORMANCE (MONO MODE) (1)(3)					
THD+N at V <sub>OUT</sub> = 0 dB	f <sub>S</sub> = 44.1 kHz		0.0004%		
	f <sub>S</sub> = 96 kHz		0.0008%		
	f <sub>S</sub> = 192 kHz		0.0015%		
Dynamic range	EIAJ, A-weighted, f <sub>S</sub> = 44.1 kHz		132		dB
	EIAJ, A-weighted, f <sub>S</sub> = 96 kHz		132		
	EIAJ, A-weighted, f <sub>S</sub> = 192 kHz		132		
Signal-to-noise ratio	EIAJ, A-weighted, f <sub>S</sub> = 44.1 kHz		132		dB
	EIAJ, A-weighted, f <sub>S</sub> = 96 kHz		132		
	EIAJ, A-weighted, f <sub>S</sub> = 192 kHz		132		

(1) Filter condition:

THD+N: 20-Hz HPF, 20-kHz apogee LPF

Dynamic range: 20-Hz HPF, 20-kHz AES17 LPF, A-weighted

Signal-to-noise ratio: 20-Hz HPF, 20-kHz AES17 LPF, A-weighted

Channel separation: 20-Hz HPF, 20-kHz AES17 LPF

Analog performance specifications are measured using the System Two™ Cascade audio measurement system by Audio Precision™ in the averaging mode.

(2) Dynamic performance and dc accuracy are specified at the output of the postamplifier as shown in Figure 24.

(3) Dynamic performance and dc accuracy are specified at the output of the postamplifier as shown in Figure 25.

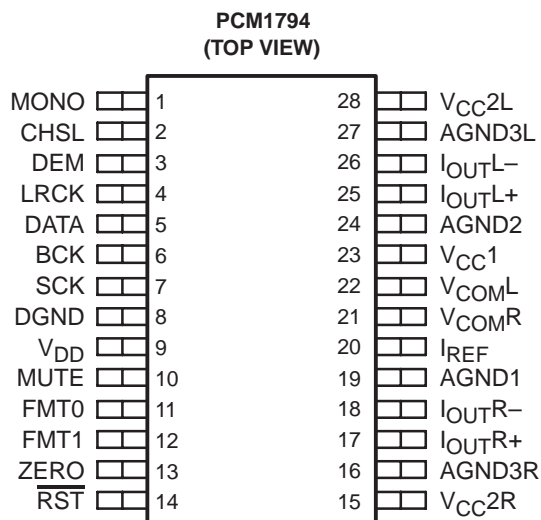
**ELECTRICAL CHARACTERISTICS (Continued)**

all specifications at  $T_A = 25^\circ\text{C}$ ,  $V_{CC1} = V_{CC2L} = V_{CC2R} = 5\text{ V}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $f_S = 44.1\text{ kHz}$ , system clock =  $256 f_S$ , and 24-bit data, unless otherwise noted

PARAMETER		TEST CONDITIONS	PCM1794DB			UNIT
			MIN	TYP	MAX	
ANALOG OUTPUT						
Gain error			−6	±2	6	% of FSR
Gain mismatch, channel-to-channel			−3	±0.5	3	% of FSR
Bipolar zero error		At BPZ	−2	±0.5	2	% of FSR
Output current		Full scale (0 dB)	7.8			mA p-p
Center current		At BPZ	−6.2			mA
DIGITAL FILTER PERFORMANCE						
De-emphasis error			±0.004			dB
FILTER CHARACTERISTICS-1: SHARP ROLLOFF						
Pass band		±0.00001 dB	0.454 f <sub>S</sub>			
		−3 dB	0.49 f <sub>S</sub>			
Stop band			0.546 f <sub>S</sub>			
Pass-band ripple			±0.00001			dB
Stop-band attenuation		Stop band = 0.546 f <sub>S</sub>	−130			dB
Delay time			55/f <sub>S</sub>			s
FILTER CHARACTERISTICS-2: SLOW ROLLOFF						
Pass band		±0.04 dB	0.254 f <sub>S</sub>			
		−3 dB	0.46 f <sub>S</sub>			
Stop band			0.732 f <sub>S</sub>			
Pass-band ripple			±0.001			dB
Stop-band attenuation		Stop band = 0.732 f <sub>S</sub>	−100			dB
Delay time			18/f <sub>S</sub>			s
POWER SUPPLY REQUIREMENTS						
V <sub>DD</sub>	Voltage range		3	3.3	3.6	VDC
V <sub>CC1</sub>						
V <sub>CC2L</sub>			4.75	5	5.25	VDC
V <sub>CC2R</sub>						
I <sub>DD</sub>	Supply current (1)	f <sub>S</sub> = 44.1 kHz	12			mA
		f <sub>S</sub> = 96 kHz	23			
		f <sub>S</sub> = 192 kHz	45			
I <sub>CC</sub>		f <sub>S</sub> = 44.1 kHz	33			mA
		f <sub>S</sub> = 96 kHz	35			
		f <sub>S</sub> = 192 kHz	37			
Power dissipation (1)		f <sub>S</sub> = 44.1 kHz	205			mW
		f <sub>S</sub> = 96 kHz	250			
		f <sub>S</sub> = 192 kHz	335			
TEMPERATURE RANGE						
Operation temperature			−25	85		°C
θ <sub>JA</sub>	Thermal resistance	28-pin SSOP	100			°C/W

(1) Input is BPZ data.

## PIN ASSIGNMENTS

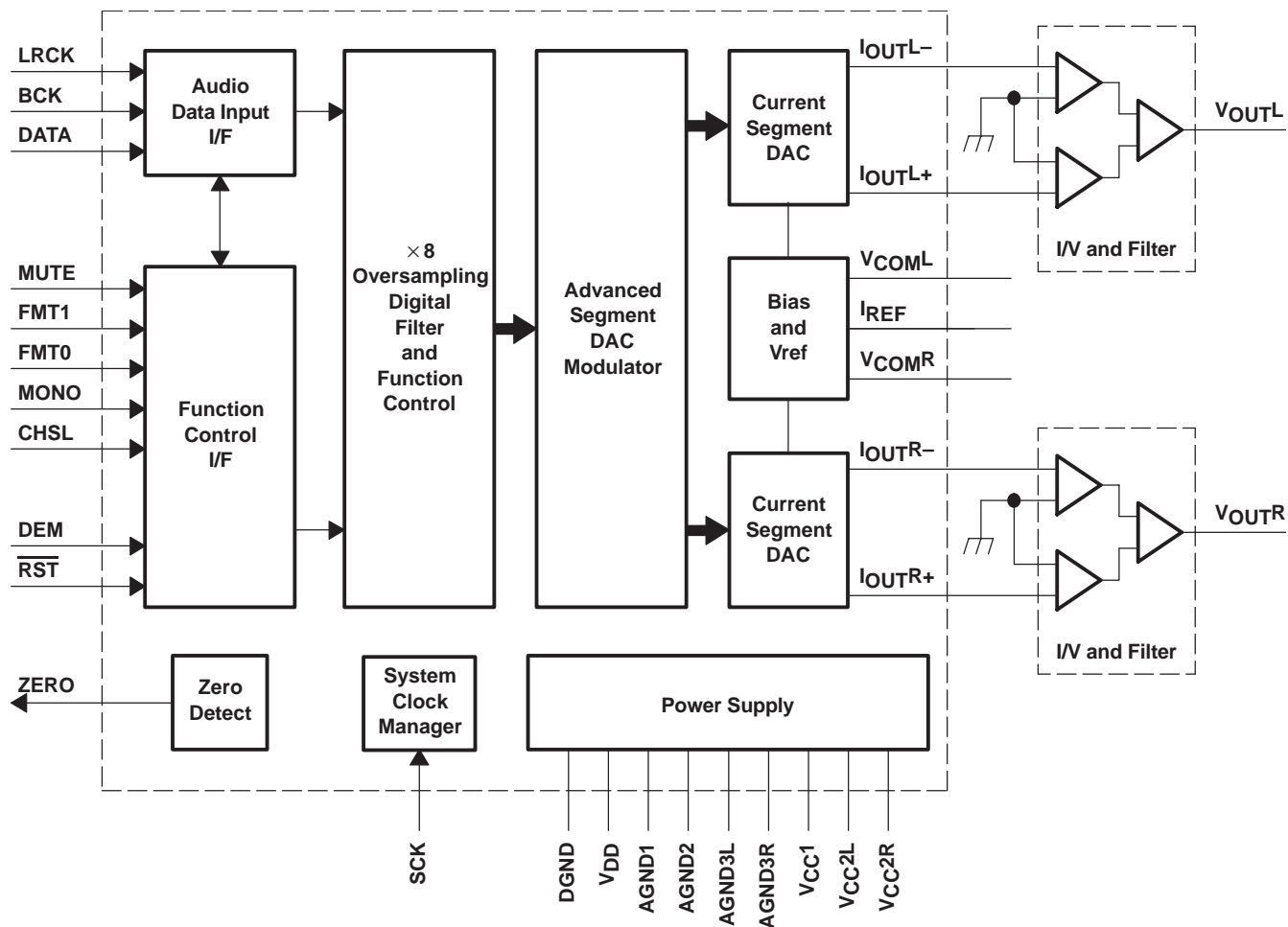


## Terminal Functions

TERMINAL NAME	PIN	I/O	DESCRIPTIONS
AGND1	19	–	Analog ground (internal bias)
AGND2	24	–	Analog ground (internal bias)
AGND3L	27	–	Analog ground (L-channel DACFF)
AGND3R	16	–	Analog ground (R-channel DACFF)
BCK	6	I	Bit clock input <sup>(1)</sup>
CHSL	2	I	L-, R-channel select <sup>(1)</sup>
DATA	5	I	Serial audio data input <sup>(1)</sup>
DEM	3	I	De-emphasis enable <sup>(1)</sup>
DGND	8	–	Digital ground
FMT0	11	I	Audio data format select <sup>(1)</sup>
FMT1	12	I	Audio data format select <sup>(1)</sup>
IOUTL+	25	O	L-channel analog current output +
IOUTL–	26	O	L-channel analog current output –
IOUTR+	17	O	R-channel analog current output +
IOUTR–	18	O	R-channel analog current output –
IREF	20	–	Output current reference bias pin
LRCK	4	I	Left and right clock (f <sub>S</sub> ) input <sup>(1)</sup>
MONO	1	I	Monaural mode enable <sup>(1)</sup>
MUTE	10	I	Mute control <sup>(1)</sup>
$\overline{\text{RST}}$	14	I	Reset <sup>(1)</sup>
SCK	7	I	System clock input <sup>(1)</sup>
VCC1	23	–	Analog power supply, 5 V
VCC2L	28	–	Analog power supply (L-channel DACFF), 5 V
VCC2R	15	–	Analog power supply (R-channel DACFF), 5 V
VCOML	22	–	L-channel internal bias decoupling pin
VCOMR	21	–	R-channel internal bias decoupling pin
VDD	9	–	Digital power supply, 3.3 V
ZERO	13	O	Zero flag

<sup>(1)</sup> Schmitt-trigger input, 5-V tolerant

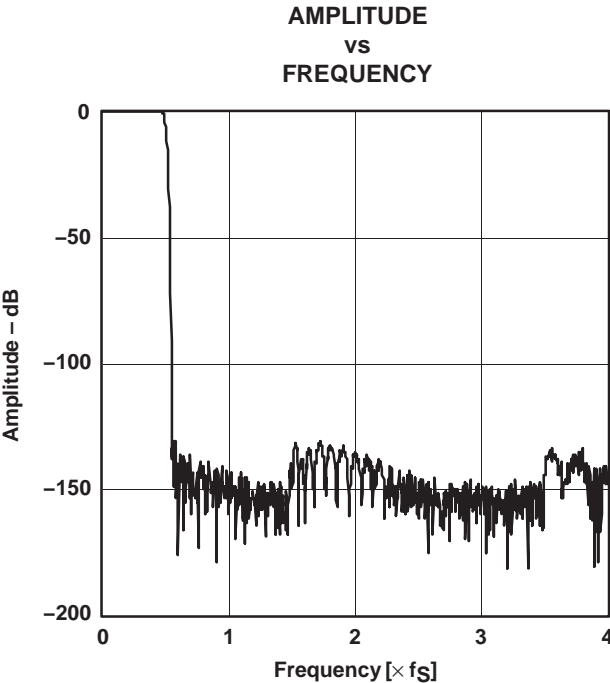
## FUNCTIONAL BLOCK DIAGRAM



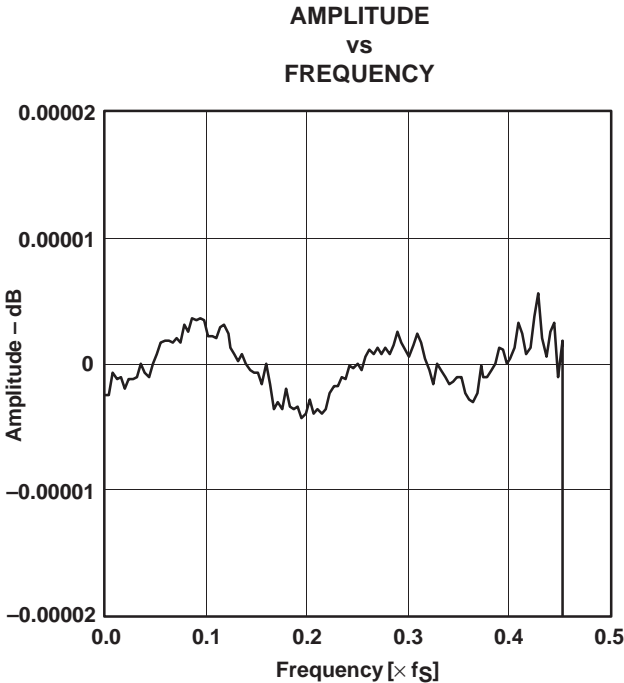
**TYPICAL PERFORMANCE CURVES**

**DIGITAL FILTER**

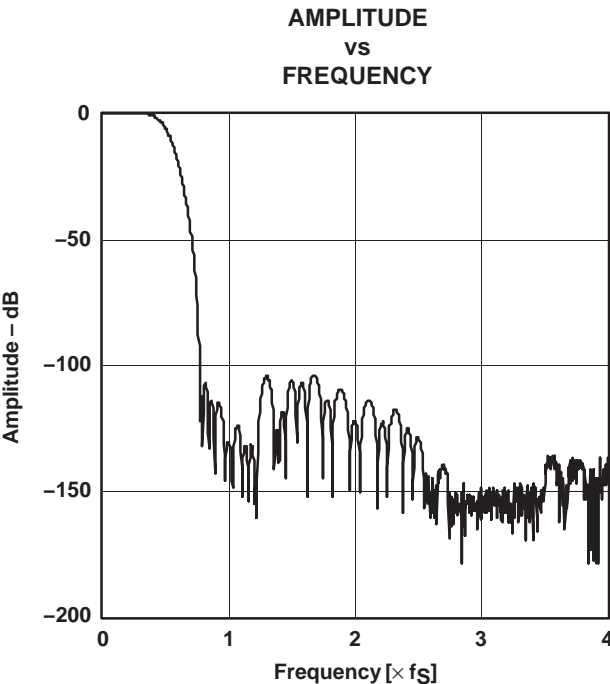
**Digital Filter Response**



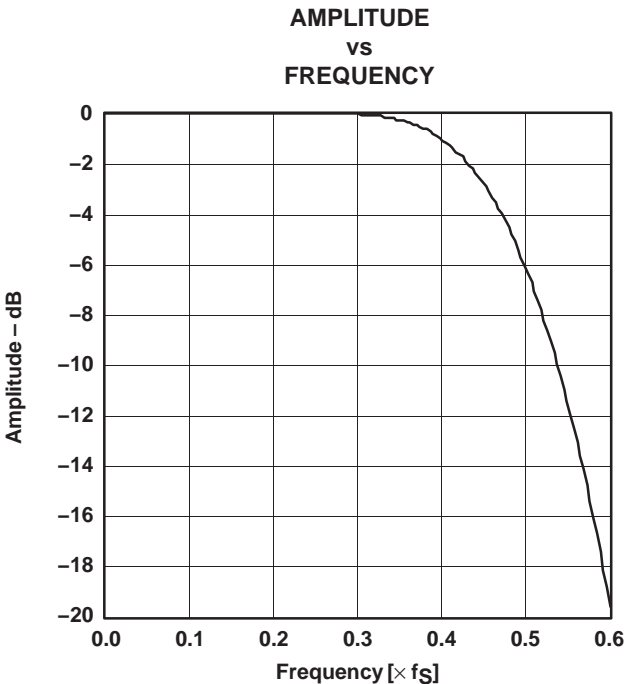
**Figure 1. Frequency Response, Sharp Rolloff**



**Figure 2. Pass-Band Ripple, Sharp Rolloff**



**Figure 3. Frequency Response, Slow Rolloff**



**Figure 4. Transition Characteristics, Slow Rolloff**



## De-Emphasis Filter

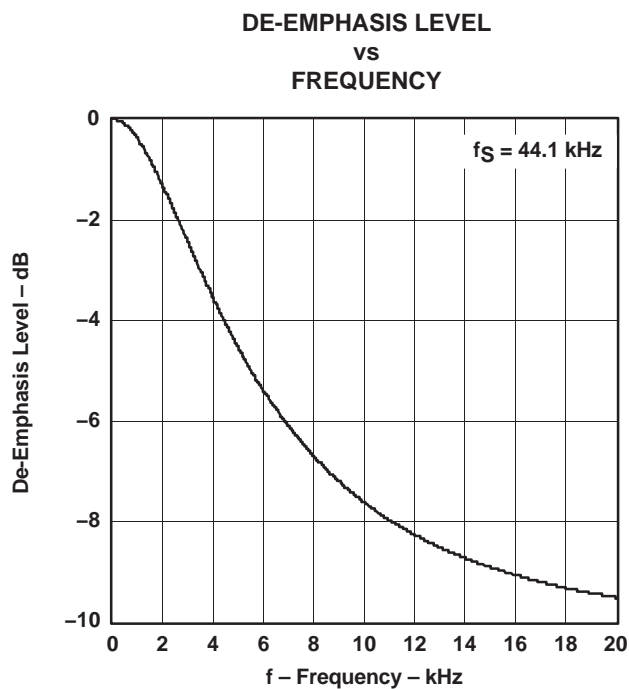


Figure 5

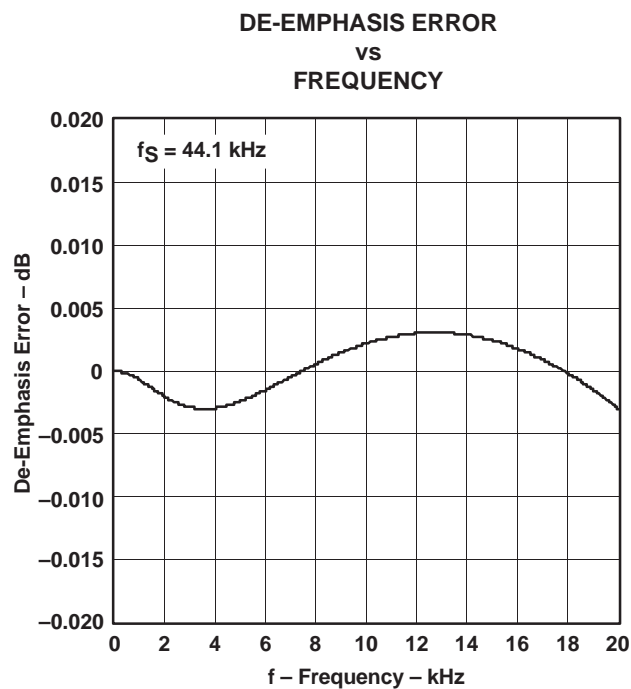


Figure 6

## ANALOG DYNAMIC PERFORMANCE

### Supply Voltage Characteristics

**TOTAL HARMONIC DISTORTION + NOISE  
vs  
SUPPLY VOLTAGE**

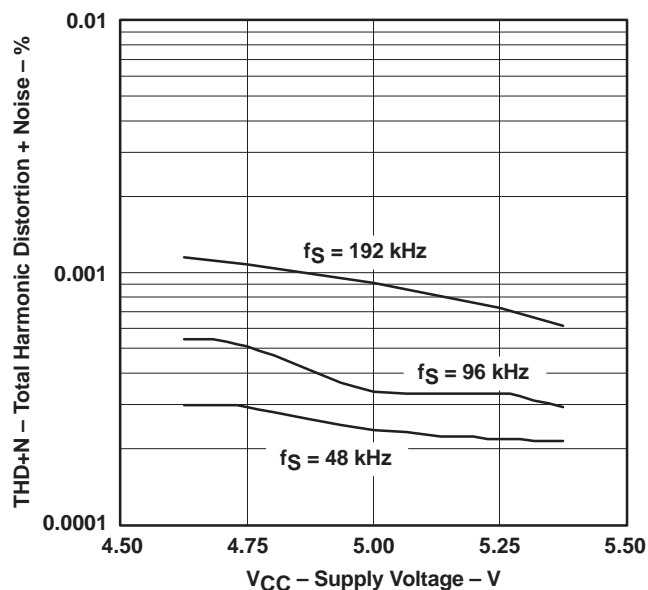


Figure 7

**DYNAMIC RANGE  
vs  
SUPPLY VOLTAGE**

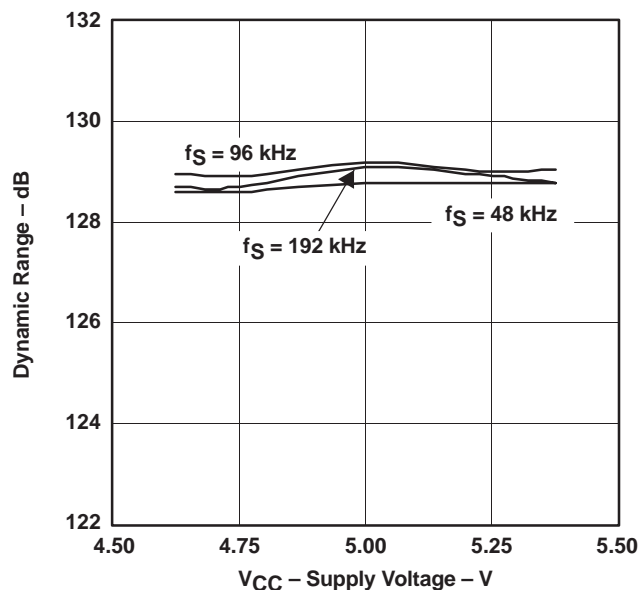


Figure 8

**SIGNAL-to-NOISE RATIO  
vs  
SUPPLY VOLTAGE**

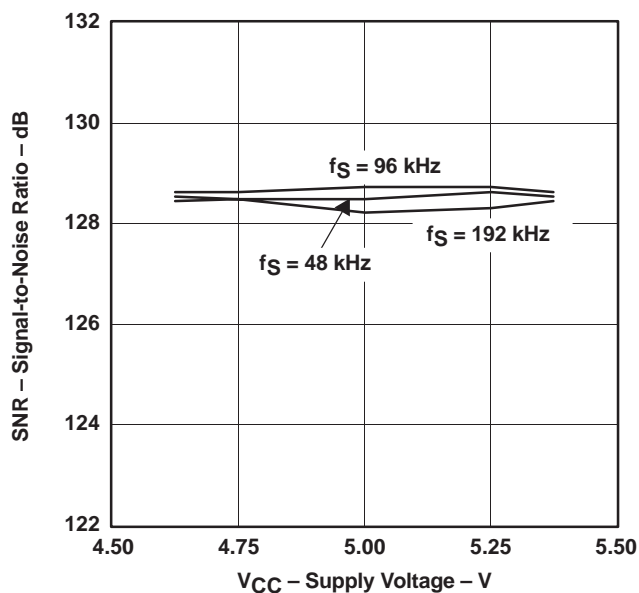


Figure 9

**CHANNEL SEPARATION  
vs  
SUPPLY VOLTAGE**

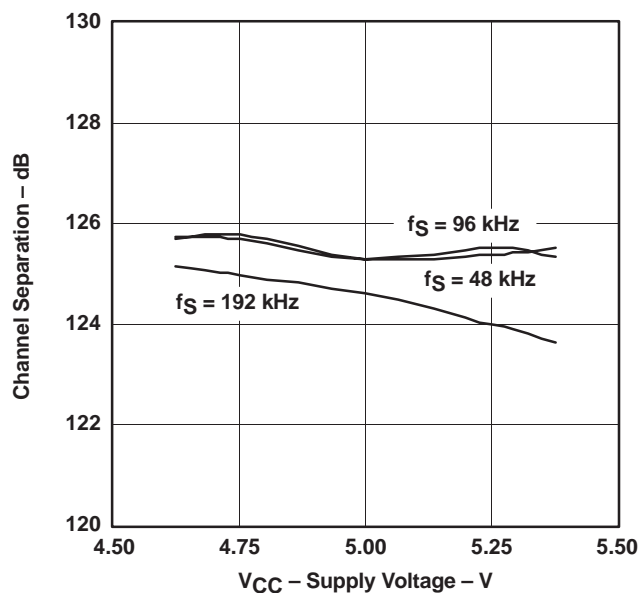


Figure 10

NOTE:  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ , measurement circuit is Figure 25 ( $V_{OUT} = 4.5\text{ V rms}$ ).

## Temperature Characteristics

**TOTAL HARMONIC DISTORTION + NOISE  
vs  
FREE-AIR TEMPERATURE**

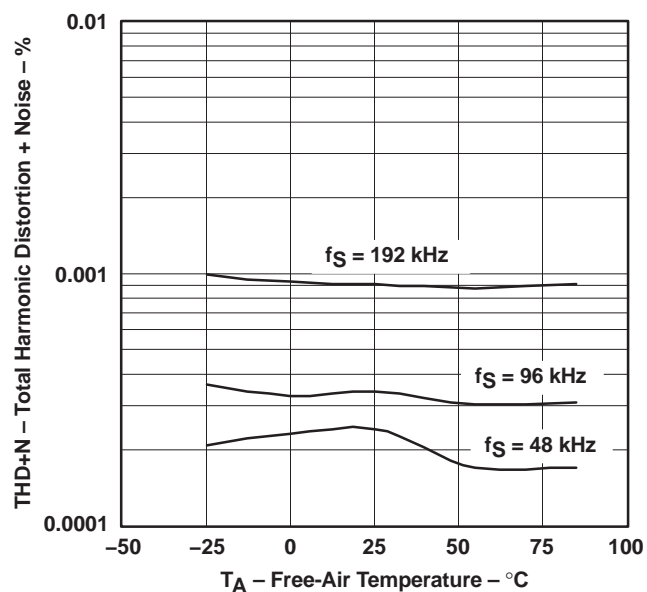


Figure 11

**DYNAMIC RANGE  
vs  
FREE-AIR TEMPERATURE**

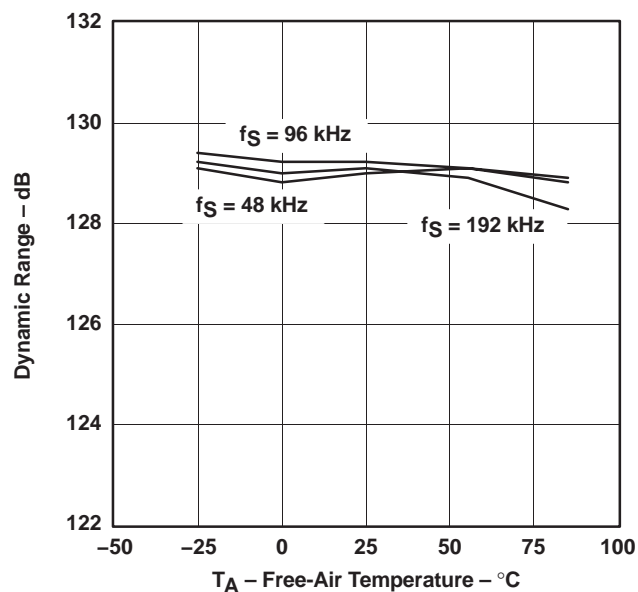


Figure 12

**SIGNAL-to-NOISE RATIO  
vs  
FREE-AIR TEMPERATURE**

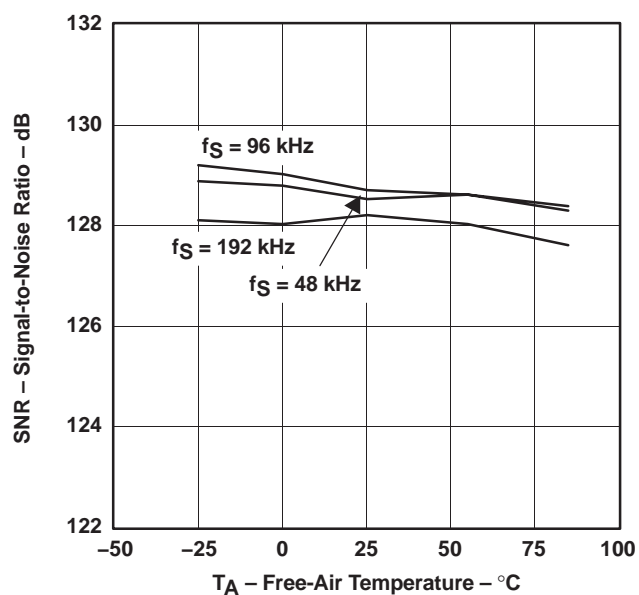


Figure 13

**CHANNEL SEPARATION  
vs  
FREE-AIR TEMPERATURE**

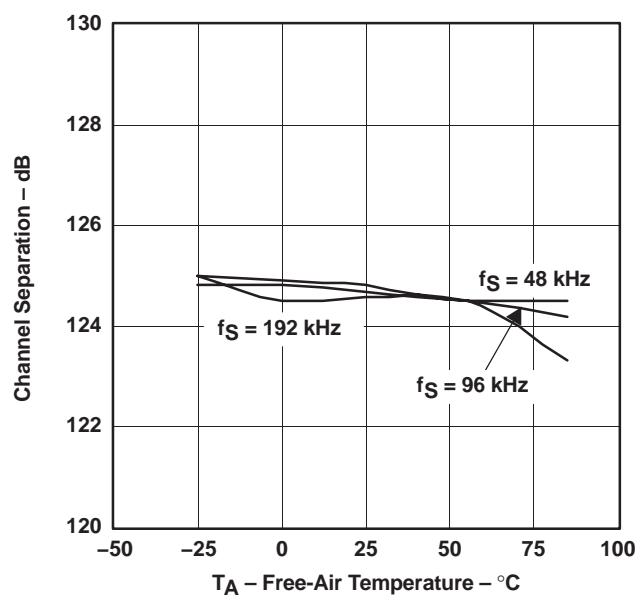
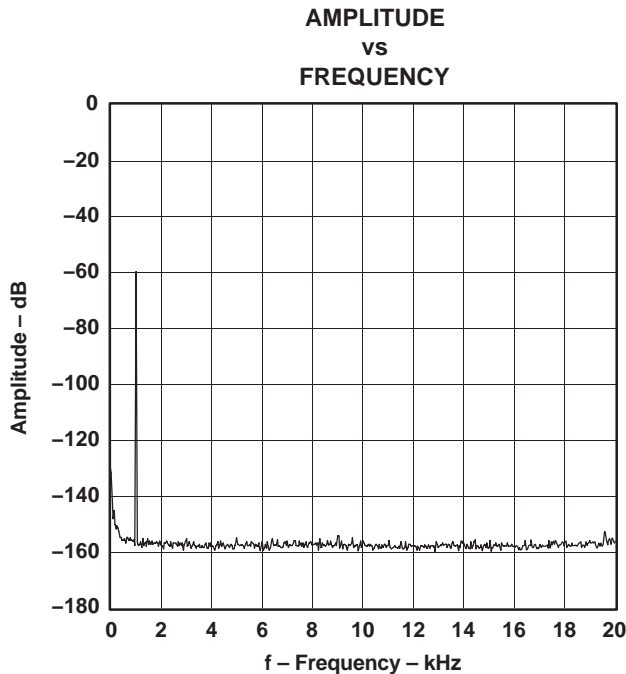


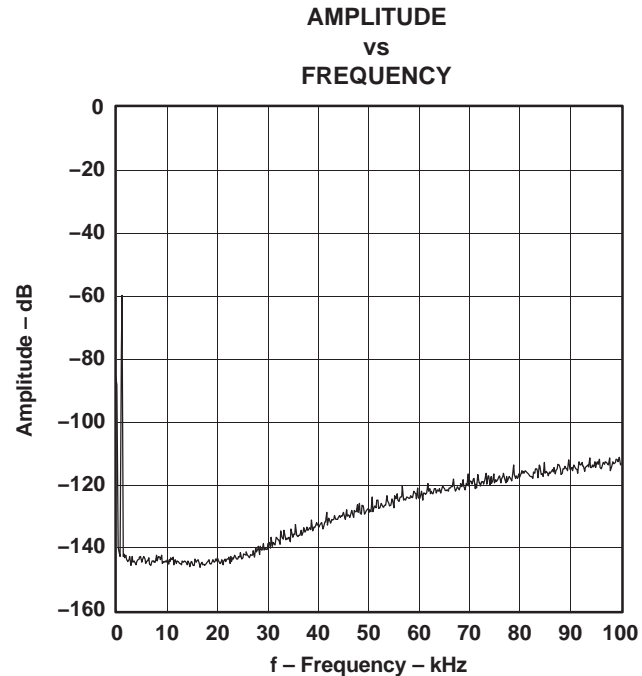
Figure 14

NOTE:  $V_{DD} = 3.3$  V,  $V_{CC} = 5$  V, measurement circuit is Figure 25 ( $V_{OUT} = 4.5$  V rms).



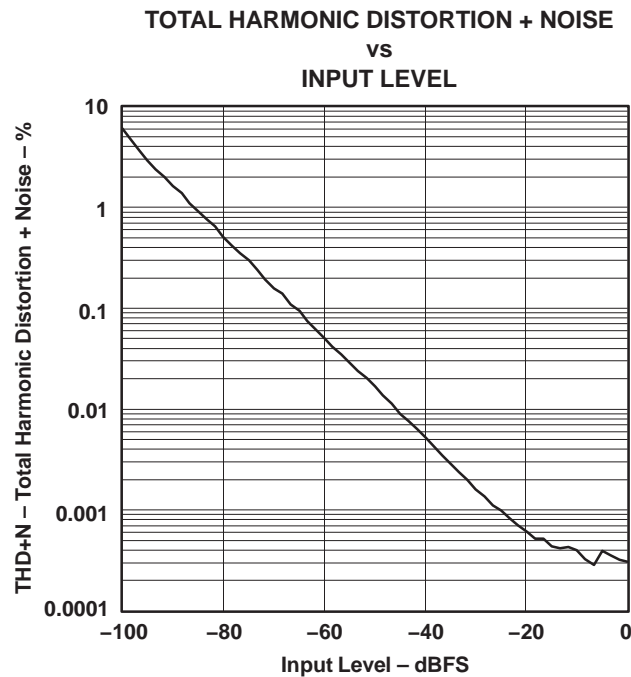
NOTE:  $f_S = 48$  kHz, 32768 point 8 average,  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3$  V,  $V_{CC} = 5$  V, measurement circuit is Figure 25.

**Figure 15. -60-dB Output Spectrum, BW = 20 kHz**



NOTE:  $f_S = 48$  kHz, 32768 point 8 average,  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3$  V,  $V_{CC} = 5$  V, measurement circuit is Figure 25.

**Figure 16. -60-dB Output Spectrum, BW = 100 kHz**



NOTE:  $f_S = 48$  kHz,  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3$  V,  $V_{CC} = 5$  V, measurement circuit is Figure 25.

**Figure 17. THD+N vs Input Level**

## SYSTEM CLOCK AND RESET FUNCTIONS

### System Clock Input

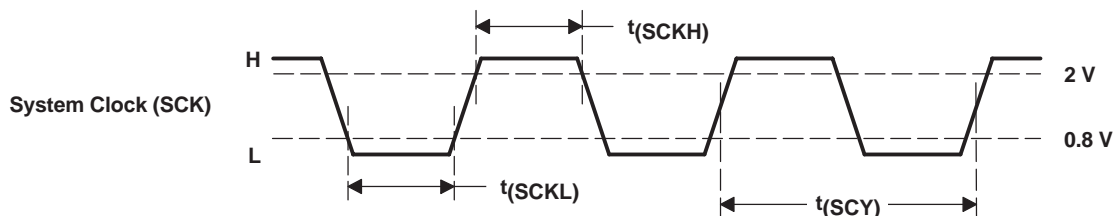
The PCM1794 requires a system clock for operating the digital interpolation filters and advanced segment DAC modulators. The system clock is applied at the SCK input (pin 7). The PCM1794 has a system clock detection circuit that automatically senses the frequency at which the system clock is operating. Table 1 shows examples of system clock frequencies for common audio sampling rates.

Figure 18 shows the timing requirements for the system clock input. For optimal performance, it is important to use a clock source with low phase jitter and noise. One of the Texas Instruments PLL1700 family of multiclock generators is an excellent choice for providing the PCM1794 system clock.

**Table 1. System Clock Rates for Common Audio Sampling Frequencies**

SAMPLING FREQUENCY	SYSTEM CLOCK FREQUENCY ( $f_{SCK}$ ) (MHz)					
	128 $f_S$	192 $f_S$	256 $f_S$	384 $f_S$	512 $f_S$	768 $f_S$
32 kHz	4.096	6.144	8.192	12.288	16.384	24.576
44.1 kHz	5.6488	8.4672	11.2896	16.9344	22.5792	33.8688
48 kHz	6.144	9.216	12.288	18.432	24.576	36.864
96 kHz	12.288	18.432	24.576	36.864	49.152	73.728
192 kHz	24.576	36.864	49.152	73.728	(1)	(1)

(1) This system clock rate is not supported for the given sampling frequency.



PARAMETERS		MIN	MAX	UNITS
$t_{SCY}$	System clock pulse cycle time	13		ns
$t_{SCKH}$	System clock pulse duration, HIGH	$0.4t_{SCY}$		ns
$t_{SCKL}$	System clock pulse duration, LOW	$0.4t_{SCY}$		ns

**Figure 18. System Clock Input Timing**

### Power-On and External Reset Functions

The PCM1794 includes a power-on reset function. Figure 19 shows the operation of this function. With  $V_{DD} > 2$  V, the power-on reset function is enabled. The initialization sequence requires 1024 system clocks from the time  $V_{DD} > 2$  V.

The PCM1794 also includes an external reset capability using the  $\overline{RST}$  input (pin 14). This allows an external controller or master reset circuit to force the PCM1794 to initialize to its default reset state.

Figure 20 shows the external reset operation and timing. The  $\overline{RST}$  pin is set to logic 0 for a minimum of 20 ns. The  $\overline{RST}$  pin is then set to a logic 1 state, thus starting the initialization sequence, which requires 1024 system clock periods. The external reset is especially useful in applications where there is a delay between the PCM1794 power up and system clock activation.

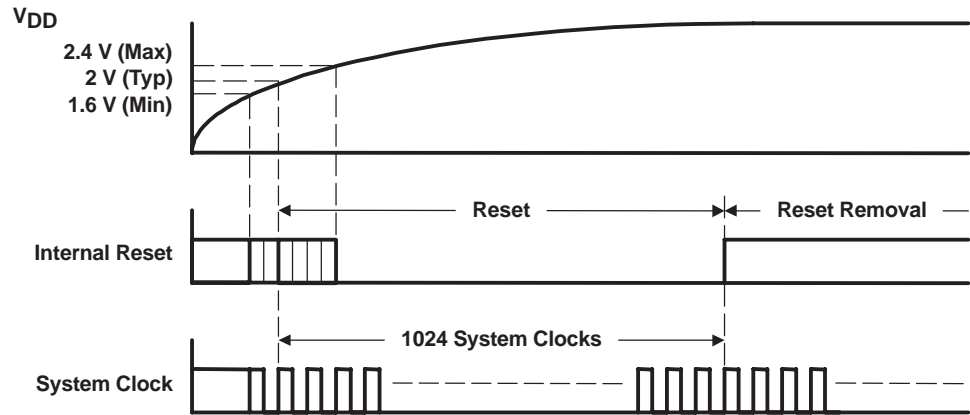
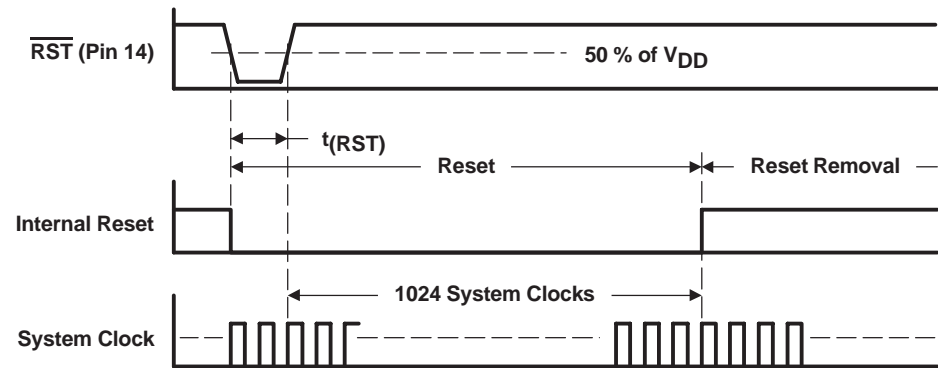


Figure 19. Power-On Reset Timing



PARAMETERS		MIN	MAX	UNITS
$t(RST)$	Reset pulse duration, LOW	20		ns

Figure 20. External Reset Timing

## AUDIO DATA INTERFACE

### Audio Serial Interface

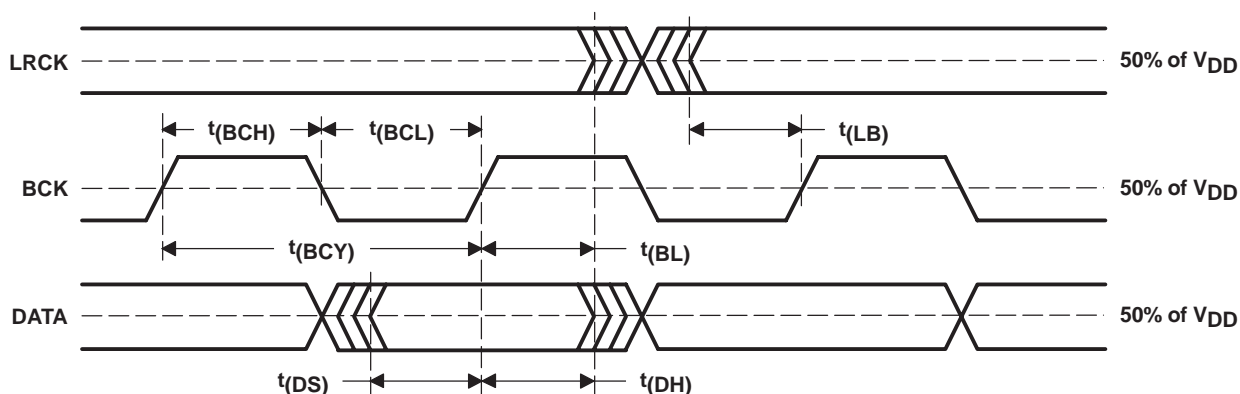
The audio interface port is a 3-wire serial port. It includes LRCK (pin 4), BCK (pin 6), and DATA (pin 5). BCK is the serial audio bit clock, and it is used to clock the serial data present on DATA into the serial shift register of the audio interface. Serial data is clocked into the PCM1794 on the rising edge of BCK. LRCK is the serial audio left/right word clock.

The PCM1794 requires the synchronization of LRCK and the system clock, but does not need a specific phase relation between LRCK and the system clock.

If the relationship between LRCK and the system clock changes more than  $\pm 6$  BCK, internal operation is initialized within  $1/f_S$  and the analog outputs are forced to the bipolar zero level until resynchronization between LRCK and the system clock is completed.

### PCM Audio Data Formats and Timing

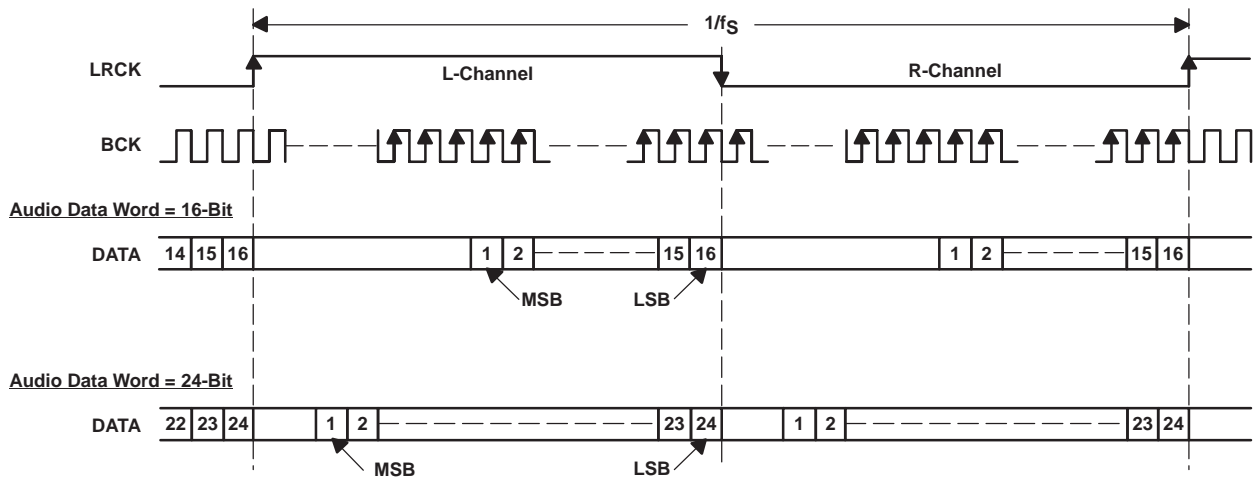
The PCM1794 supports industry-standard audio data formats, including standard right-justified, I<sup>2</sup>S, and left-justified. The data formats are shown in Figure 22. Data formats are selected using the format bits, FMT1 (pin 12), and FMT0 (pin 11) as shown in Table 2. All formats require binary twos-complement, MSB-first audio data. Figure 21 shows a detailed timing diagram for the serial audio interface.



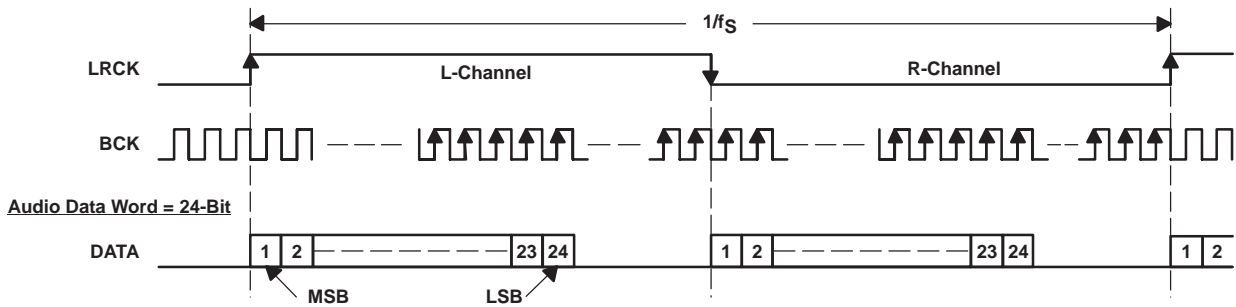
PARAMETERS		MIN	MAX	UNITS
t(BCY)	BCK pulse cycle time	70		ns
t(BCL)	BCK pulse duration, LOW	30		ns
t(BCH)	BCK pulse duration, HIGH	30		ns
t(BL)	BCK rising edge to LRCK edge	10		ns
t(LB)	LRCK edge to BCK rising edge	10		ns
t(DS)	DATA setup time	10		ns
t(DH)	DATA hold time	10		ns
—	LRCK clock duty	50% $\pm$ 2 bit clocks		

Figure 21. Timing of Audio Interface

**(1) Standard Data Format (Right Justified); L-Channel = HIGH, R-Channel = LOW**



**(2) Left Justified Data Format; L-Channel = HIGH, R-Channel = LOW**



**(3) I<sup>2</sup>S Data Format; L-Channel = LOW, R-Channel = HIGH**

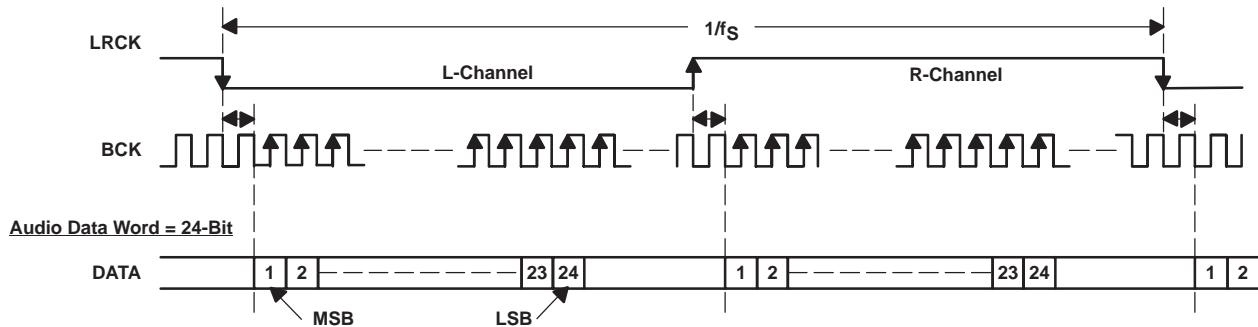


Figure 22. Audio Data Input Formats



## FUNCTION DESCRIPTIONS

### Audio data format

Audio format is selected using FMT0 (pin 11) and FMT1 (pin 12). The PCM1794 also supports monaural mode and DF bypass mode using MONO (pin 1) and CHSL (pin 2). The PCM1794 can select the DF rolloff characteristics.

**Table 2. Audio Data Format Select**

MONO	CHSL	FMT1	FMT0	FORMAT	STEREO/MONO	DF ROLLOFF
0	0	0	0	I <sup>2</sup> S	Stereo	Sharp
0	0	0	1	Left-justified format	Stereo	Sharp
0	0	1	0	Standard, 16-bit	Stereo	Sharp
0	0	1	1	Standard, 24-bit	Stereo	Sharp
0	1	0	0	I <sup>2</sup> S	Stereo	Slow
0	1	0	1	Left-justified format	Stereo	Slow
0	1	1	0	Standard, 16-bit	Stereo	Slow
0	1	1	1	Digital filter bypass	Mono	–
1	0	0	0	I <sup>2</sup> S	Mono, L-channel	Sharp
1	0	0	1	Left-justified format	Mono, L-channel	Sharp
1	0	1	0	Standard, 16-bit	Mono, L-channel	Sharp
1	0	1	1	Standard, 24-bit	Mono, L-channel	Sharp
1	1	0	0	I <sup>2</sup> S	Mono, R-channel	Sharp
1	1	0	1	Left-justified format	Mono, R-channel	Sharp
1	1	1	0	Standard, 16-bit	Mono, R-channel	Sharp
1	1	1	1	Standard, 24-bit	Mono, R-channel	Sharp

### Soft Mute

The PCM1794 supports mute operation. When MUTE (pin 10) is set to HIGH, both analog outputs are transitioned to the bipolar zero level in –0.5-dB steps with a transition speed of  $1/f_s$  per step. This system provides pop-free muting of the DAC output.

### De-Emphasis

The PCM1794 has a de-emphasis filters for the sampling frequency of 44.1 kHz. The de-emphasis filter is controlled using DEM (pin 3).

### Zero Detect

When the PCM1794 detects that the audio input data in the L-channel and the R-channel is continuously zero for 1024 LRCKs in the PCM mode or that the audio input data is continuously zero for 1024 WDCKs in the external filter mode, the PCM1794 sets ZERO (pin 13) to HIGH.

# TYPICAL CONNECTION DIAGRAM

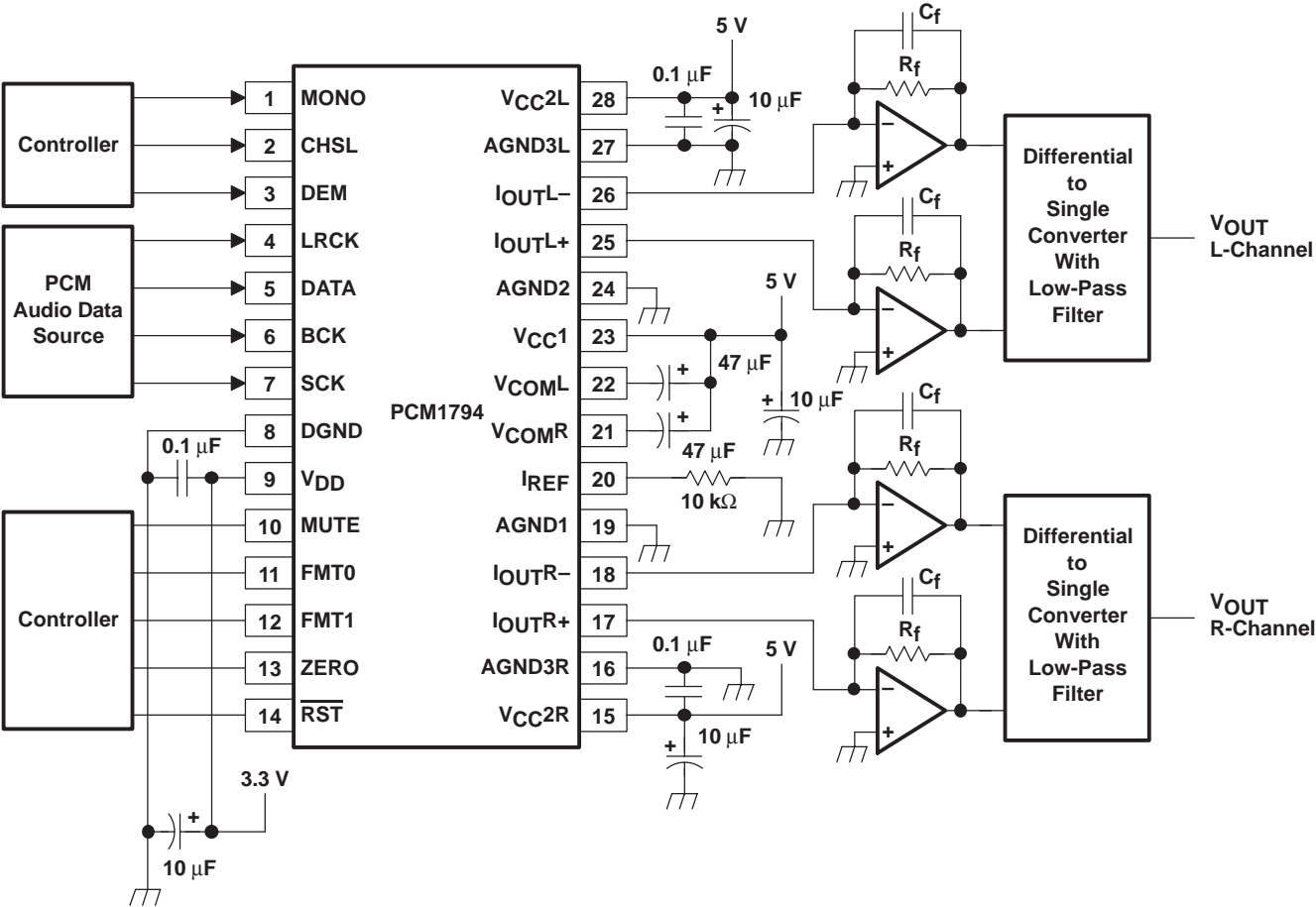


Figure 23. Typical Application Circuit

---

## APPLICATION INFORMATION

### APPLICATION CIRCUIT

The design of the application circuit is very important in order to actually realize the high S/N ratio of which the PCM1794 is capable. This is because noise and distortion that are generated in an application circuit are not negligible.

In the circuit of Figure 24, the output level is 2 V RMS, and 127 dB S/N is achieved. The circuit of Figure 25 can realize the highest performance. In this case the output level is set to 4.5 V RMS and 129 dB S/N is achieved (stereo mode). In monaural mode, if the output of the L-channel and R-channel is used as a balanced output, 132 dB S/N is achieved (see Figure 26).

### I/V Section

The current of the PCM1794 on each of the output pins ( $I_{OUTL+}$ ,  $I_{OUTL-}$ ,  $I_{OUTR+}$ ,  $I_{OUTR-}$ ) is 7.8 mA p-p at 0 dB (full scale). The voltage output level of the I/V converter ( $V_i$ ) is given by following equation:

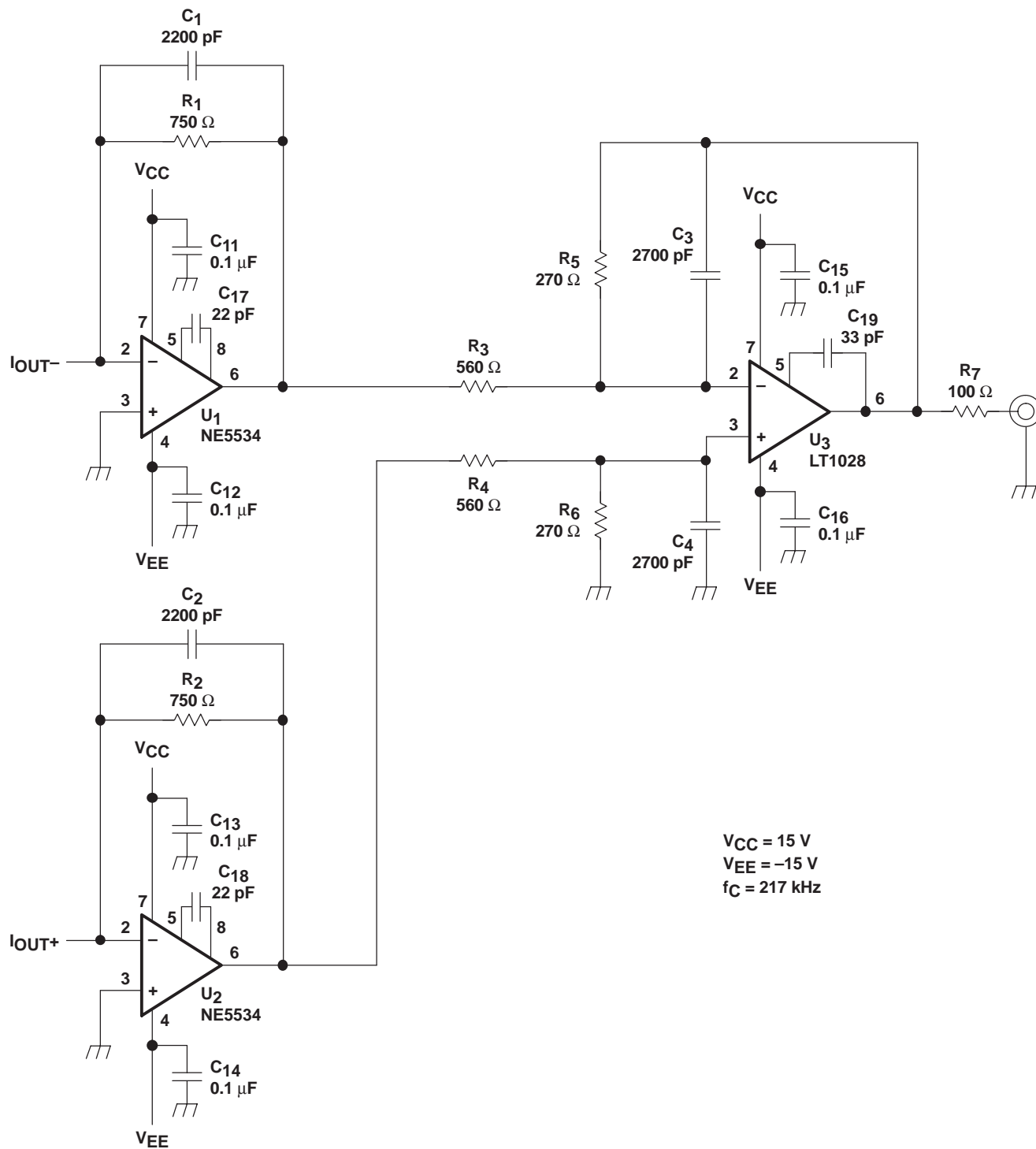
$$V_i = 7.8 \text{ mA p-p} \times R_f \text{ (} R_f : \text{ feedback resistance of I/V converter)}$$

An NE5534 operational amplifier is recommended for the I/V circuit to obtain the specified performance. Dynamic performance such as the gain bandwidth, settling time, and slew rate of the operational amplifier affects the audio dynamic performance of the I/V section.

### Differential Section

The PCM1794 voltage outputs are followed by differential amplifier stages, which sum the differential signals for each channel, creating a single-ended I/V op-amp output. In addition, the differential amplifiers provide a low-pass filter function.

The operational amplifier recommended for the differential circuit is the Linear Technology LT1028, because its input noise is low.

Figure 24. Measurement Circuit,  $V_{OUT} = 2\text{ V RMS}$

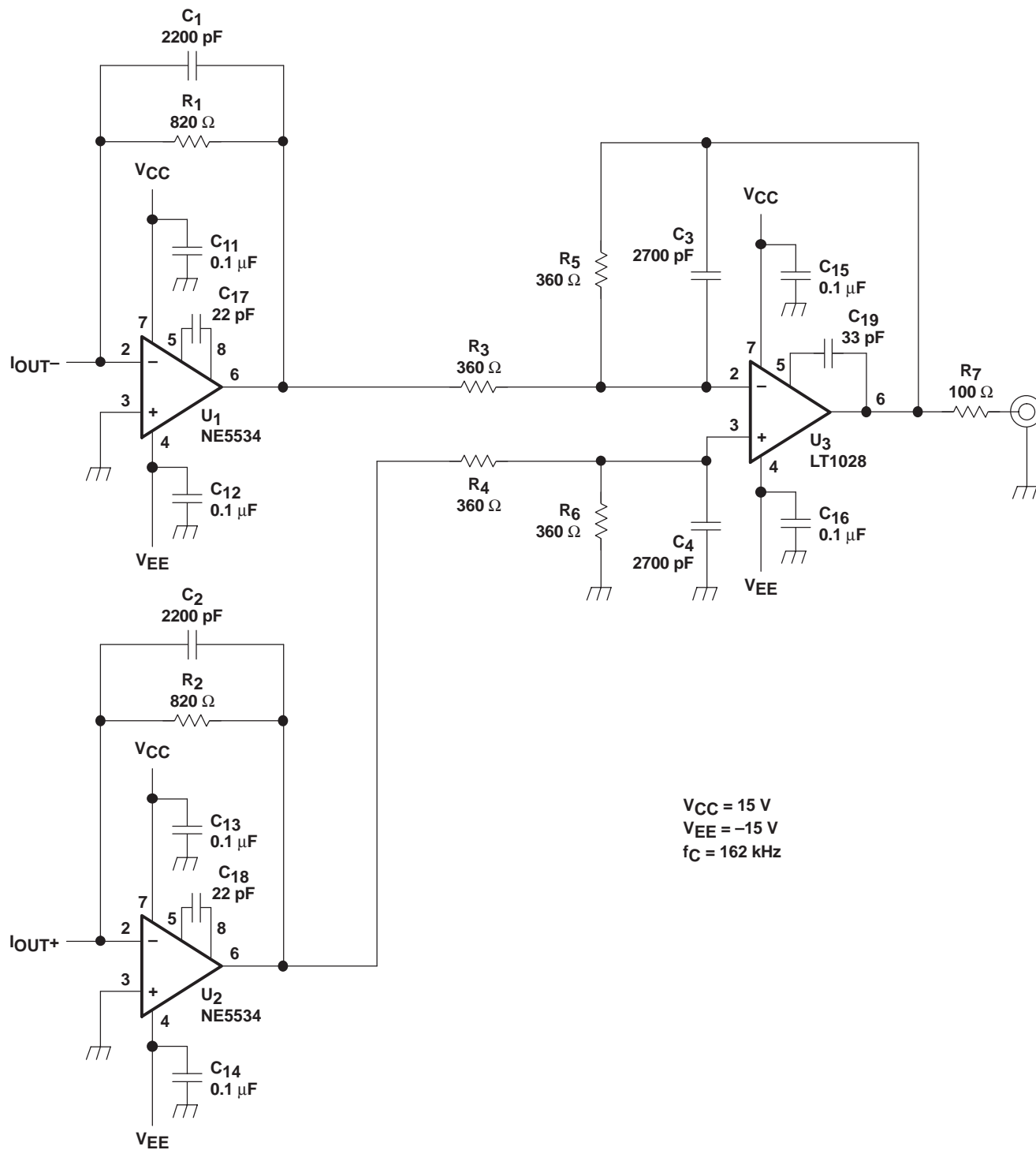


Figure 25. Measurement Circuit,  $V_{OUT} = 4.5\ \text{V RMS}$

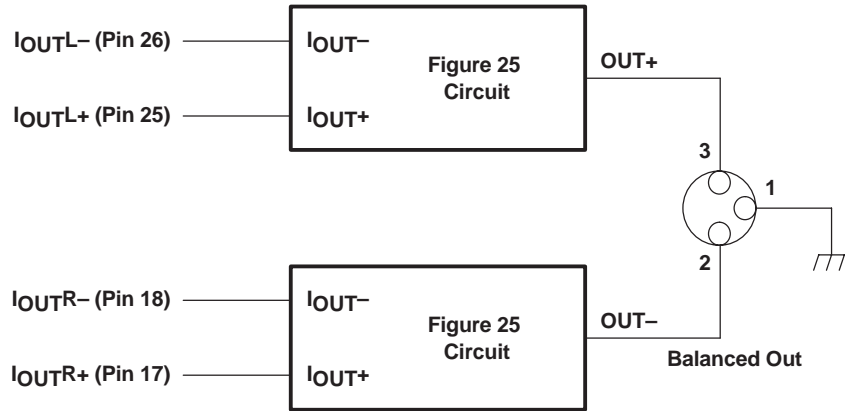


Figure 26. Measurement Circuit for Monaural Mode

APPLICATION FOR EXTERNAL DIGITAL FILTER INTERFACE

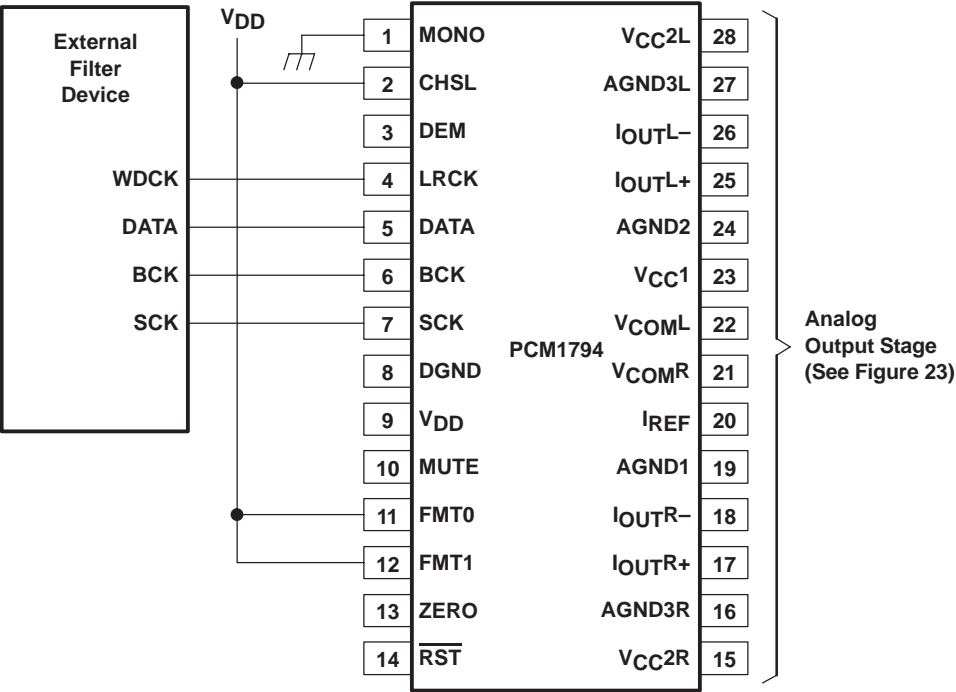


Figure 27. Connection Diagram for External Digital Filter (Internal DF Bypass Mode) Application

## Application for Interfacing With an External Digital Filter

For some applications, it may be desirable to use a programmable digital signal processor as an external digital filter to perform the interpolation function. The following pin settings enable the external digital filter application mode.

- MONO (pin 1) = LOW
- CHSL (Pin 2) = HIGH
- FMT0 (Pin 11) = HIGH
- FMT1 (pin 12) = HIGH

The pins used to provide the serial interface for the external digital filter are shown in the connection diagram of Figure 27. The word clock (WDCK) must be operated at  $8\times$  or  $4\times$  the desired sampling frequency,  $f_s$ .

## System Clock (SCK) and Interface Timing

The PCM1794 in an application using an external digital filter requires the synchronization of WDCK and the system clock. The system clock is phase-free with respect to WDCK. Interface timing among WDCK, BCK, and DATA is shown in Figure 29.

## Audio Format

The PCM1794 in the external digital filter interface mode supports right-justified audio formats including 24-bit audio data, as shown in Figure 28.

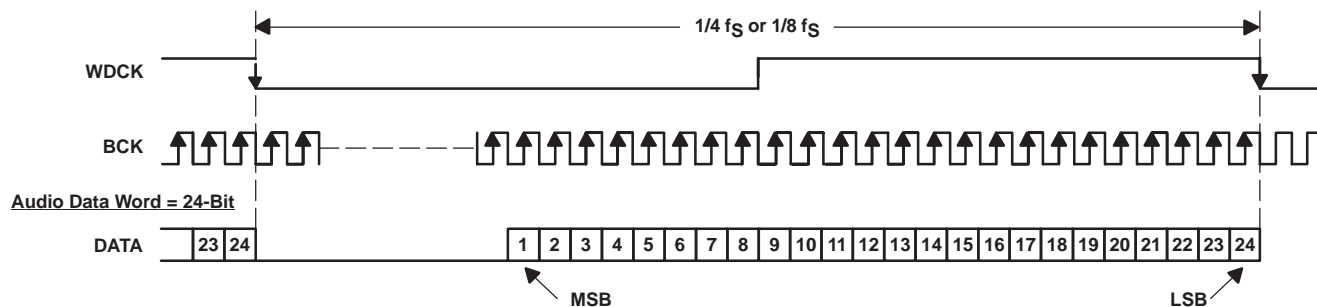
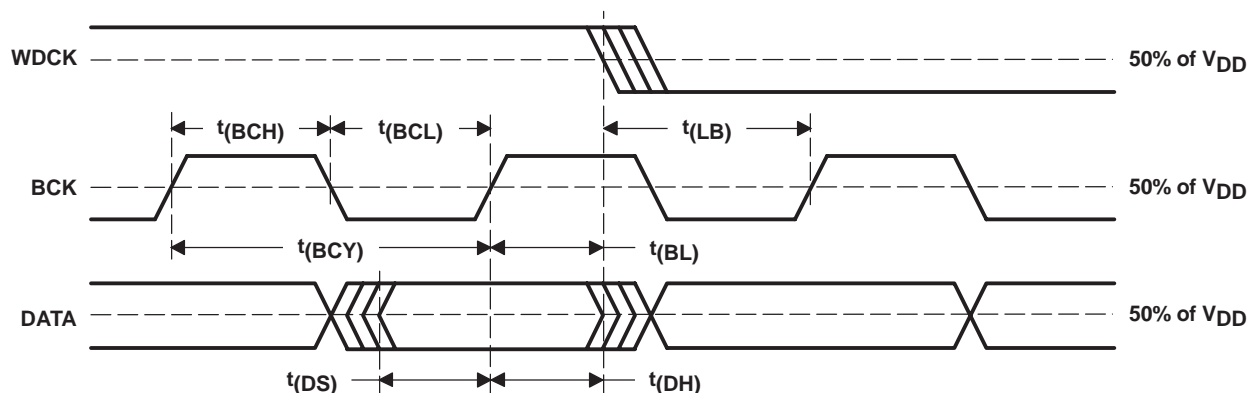


Figure 28. Audio Data Input Format for External Digital Filter (Internal DF Bypass Mode) Application



PARAMETER	MIN	MAX	UNITS
$t(BCY)$ BCK pulse cycle time	20		ns
$t(BCL)$ BCK pulse duration, LOW	7		ns
$t(BCH)$ BCK pulse duration, HIGH	7		ns
$t(BL)$ BCK rising edge to WDCK falling edge	5		ns
$t(LB)$ WDCK falling edge to BCK rising edge	5		ns
$t(DS)$ DATA setup time	5		ns
$t(DH)$ DATA hold time	5		ns

Figure 29. Audio Interface Timing for External Digital Filter (Internal DF Bypass Mode) Application

## THEORY OF OPERATION

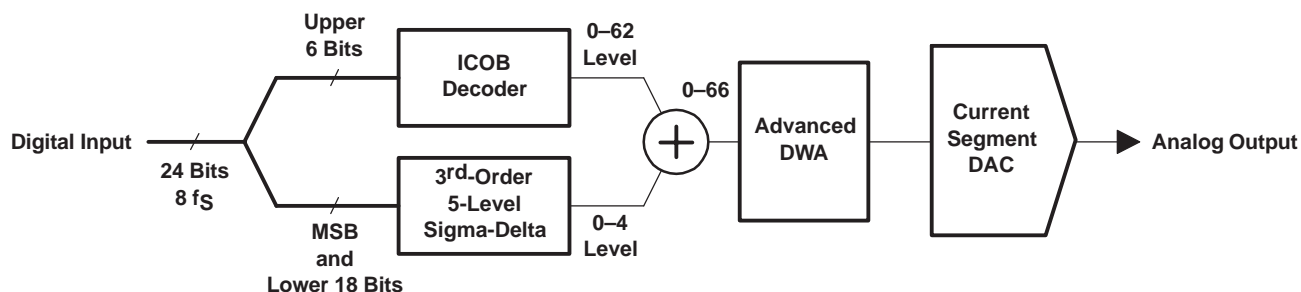


Figure 30. Advanced Segment DAC

The PCM1794 uses TI's advanced segment DAC architecture to achieve excellent dynamic performance and improved tolerance to clock jitter. The PCM1794 provides balanced current outputs.

Digital input data via the digital filter is separated into 6 upper bits and 18 lower bits. The 6 upper bits are converted to inverted complementary offset binary (ICOB) code. The lower 18 bits, associated with the MSB, are processed by a five-level third-order delta-sigma modulator operated at  $64 f_s$  by default. The 1 level of the modulator is equivalent to the 1 LSB of the ICOB code converter. The data groups processed in the ICOB converter and third-order delta-sigma modulator are summed together to create an up-to-66-level digital code, and then processed by data-weighted averaging (DWA) to reduce the noise produced by element mismatch. The data of up to 66 levels from the DWA is converted to an analog output in the differential-current segment section.

This architecture has overcome the various drawbacks of conventional multibit processing and also achieves excellent dynamic performance.



## Analog output

The following table and Figure 31 show the relationship between the digital input code and analog output.

	800000 (–FS)	000000 (BPZ)	7FFFFFF (+FS)
$I_{OUTN}$ [mA]	–2.3	–6.2	–10.1
$I_{OUTP}$ [mA]	–10.1	–6.2	–2.3
$V_{OUTN}$ [V]	–1.725	–4.65	–7.575
$V_{OUTP}$ [V]	–7.575	–4.65	–1.725
$V_{OUT}$ [V]	–2.821	0	2.821

NOTE:  $V_{OUTN}$  is the output of U1,  $V_{OUTP}$  is the output of U2, and  $V_{OUT}$  is the output of U3 in the measurement circuit of Figure 24.

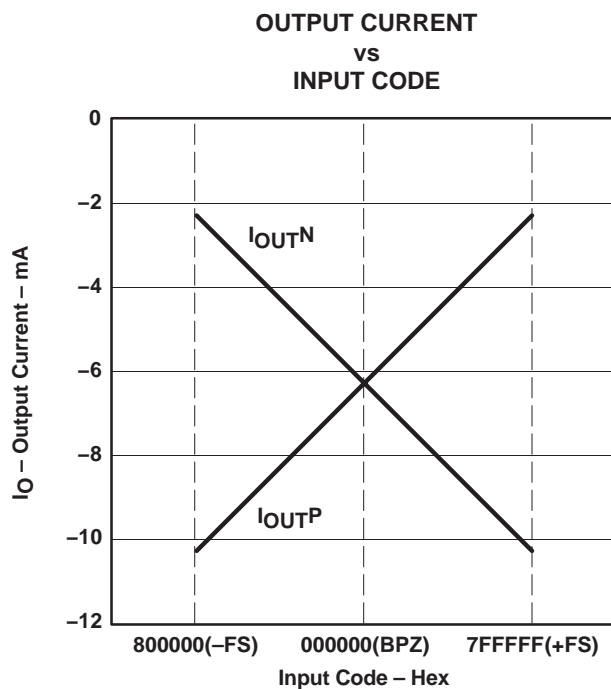


Figure 31. The Relationship Between Digital Input and Analog Output

## PACKAGING INFORMATION

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
PCM1794DB	NRND	SSOP	DB	28	47	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCM1794DBG4	NRND	SSOP	DB	28	47	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCM1794DBR	NRND	SSOP	DB	28	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCM1794DBRG4	NRND	SSOP	DB	28	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**TAPE AND REEL INFORMATION**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
PCM1794DBR	SSOP	DB	28	2000	330.0	17.4	8.5	10.8	2.4	12.0	16.0	Q1

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
PCM1794DBR	SSOP	DB	28	2000	336.6	336.6	28.6

## DB (R-PDSO-G\*\*)

## PLASTIC SMALL-OUTLINE

28 PINS SHOWN



- 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 0,15.  
 D. Falls within JEDEC MO-150

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2009, Texas Instruments Incorporated