



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

FEATURES

- 24-Bit Resolution
- Analog Performance:
 - Dynamic Range: 123 dB
 - THD+N: 0.0005%
- Differential Current Output: 4 mA p-p
- 8× Oversampling Digital Filter:
 - Stop-Band Attenuation: –98 dB
 - Pass-Band Ripple: ±0.0002 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, I²S, and Left-Justified
- Interface Available for Optional 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
- Pin Assignment Compatible With PCM1794

APPLICATIONS

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

DESCRIPTION

The PCM1798 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 PCM1798 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 |
|-----------|--------------|--------------|-----------------------------|-----------------|-----------------|-----------------|
| PCM1798DB | 28-lead SSOP | 28DB | –25°C to 85°C | PCM1798 | PCM1798DB | Tube |
| | | | | | PCM1798DBR | Tape and reel |

ABSOLUTE MAXIMUM RATINGSover operating free-air temperature range unless otherwise noted⁽¹⁾

| | | PCM1798 |
|--|---|--|
| Supply voltage | $V_{CC1}, V_{CC2L}, V_{CC2R}$ | –0.3 V to 6.5 V |
| | V_{DD} | –0.3 V to 4 V |
| Supply voltage differences: $V_{CC1}, V_{CC2L}, V_{CC2R}$ | | ±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 $(V_{DD} + 0.3 \text{ V}) < 4 \text{ V}$ |
| Analog input voltage | | –0.3 V to $(V_{CC} + 0.3 \text{ V}) < 6.5 \text{ V}$ |
| 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) | | 260°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 $T_A = 25^\circ\text{C}$, $V_{CC1} = V_{CC2L} = V_{CC2R} = 5 \text{ V}$, $V_{DD} = 3.3 \text{ V}$, $f_S = 44.1 \text{ kHz}$, system clock = 256 f_S , and 24-bit data, unless otherwise noted

| PARAMETER | TEST CONDITIONS | PCM1798DB | | | UNIT |
|-----------------------------|-----------------------------|------------------------------------|--|-----|---------------|
| | | MIN | TYP | MAX | |
| RESOLUTION | | | 24 | | Bits |
| DATA FORMAT | | | | | |
| | Audio data interface format | | Standard, I ² S, left-justified | | |
| | Audio data bit length | | 16-, 24-bit selectable | | |
| | Audio data format | | MSB first, 2s complement | | |
| f_S | Sampling frequency | 10 | 200 | | kHz |
| | System clock frequency | 128, 192, 256, 384, 512, 768 f_S | | | |
| DIGITAL INPUT/OUTPUT | | | | | |
| | Logic family | | TTL compatible | | |
| V_{IH} | Input logic level | | 2 | | VDC |
| V_{IL} | | | | 0.8 | |
| I_{IH} | Input logic current | $V_{IN} = V_{DD}$ | | 10 | μA |
| I_{IL} | | $V_{IN} = 0 \text{ V}$ | | –10 | |
| V_{OH} | Output logic level | $I_{OH} = -2 \text{ mA}$ | 2.4 | | VDC |
| V_{OL} | | $I_{OL} = 2 \text{ mA}$ | | 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 | PCM1798DB | | | UNIT |
|--|---|-----------|---------|--------|------|
| | | MIN | TYP | MAX | |
| DYNAMIC PERFORMANCE (1)(2) | | | | | |
| THD+N at $V_{OUT} = 0\text{ dB}$ | $f_S = 44.1\text{ kHz}$ | | 0.0005% | 0.001% | |
| | $f_S = 96\text{ kHz}$ | | 0.001% | | |
| | $f_S = 192\text{ kHz}$ | | 0.0015% | | |
| Dynamic range | EIAJ, A-weighted, $f_S = 44.1\text{ kHz}$ | 120 | 123 | | dB |
| | EIAJ, A-weighted, $f_S = 96\text{ kHz}$ | | 123 | | |
| | EIAJ, A-weighted, $f_S = 192\text{ kHz}$ | | 123 | | |
| Signal-to-noise ratio | EIAJ, A-weighted, $f_S = 44.1\text{ kHz}$ | 120 | 123 | | dB |
| | EIAJ, A-weighted, $f_S = 96\text{ kHz}$ | | 123 | | |
| | EIAJ, A-weighted, $f_S = 192\text{ kHz}$ | | 123 | | |
| Channel separation | $f_S = 44.1\text{ kHz}$ | 116 | 119 | | dB |
| | $f_S = 96\text{ kHz}$ | | 118 | | |
| | $f_S = 192\text{ kHz}$ | | 117 | | |
| Level linearity error | $V_{OUT} = -120\text{ dB}$ | | ± 1 | | dB |
| DYNAMIC PERFORMANCE (MONO MODE) (1)(2)(3) | | | | | |
| THD+N at $V_{OUT} = 0\text{ dB}$ | $f_S = 44.1\text{ kHz}$ | | 0.0005% | | |
| | $f_S = 96\text{ kHz}$ | | 0.001% | | |
| | $f_S = 192\text{ kHz}$ | | 0.0015% | | |
| Dynamic range | EIAJ, A-weighted, $f_S = 44.1\text{ kHz}$ | | 126 | | dB |
| | EIAJ, A-weighted, $f_S = 96\text{ kHz}$ | | 126 | | |
| | EIAJ, A-weighted, $f_S = 192\text{ kHz}$ | | 126 | | |
| Signal-to-noise ratio | EIAJ, A-weighted, $f_S = 44.1\text{ kHz}$ | | 126 | | dB |
| | EIAJ, A-weighted, $f_S = 96\text{ kHz}$ | | 126 | | |
| | EIAJ, A-weighted, $f_S = 192\text{ kHz}$ | | 126 | | |

(1) Filter condition:

THD+N: 20-Hz HPF, 20-kHz AES17 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 measurement circuit as shown in Figure 25.

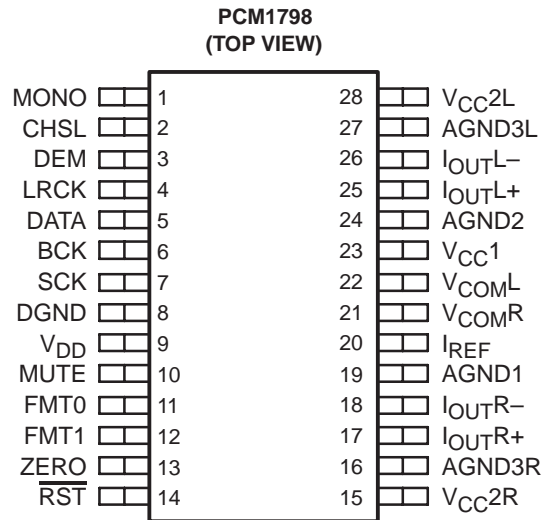
ELECTRICAL CHARACTERISTICS (Continued)

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 | PCM1798DB | | | UNIT | |
|--|-------------------------|-------------------------|-----------|--------------|--------------------|-----|
| | | MIN | TYP | MAX | | |
| ANALOG OUTPUT | | | | | | |
| Gain error | | -7 | ± 2 | 7 | % 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) | | 4 | | mA p-p | |
| Center current | At BPZ | | -3.5 | | mA | |
| DIGITAL FILTER PERFORMANCE | | | | | | |
| De-emphasis error | | | | ± 0.1 | dB | |
| FILTER CHARACTERISTICS-1: SHARP ROLLOFF | | | | | | |
| Pass band | $\pm 0.0002\text{ dB}$ | | | $0.454 f_S$ | | |
| | -3 dB | | | $0.49 f_S$ | | |
| Stop band | | $0.546 f_S$ | | | | |
| Pass-band ripple | | | | ± 0.0002 | dB | |
| Stop-band attenuation | Stop band = $0.546 f_S$ | -98 | | | dB | |
| Delay time | | | $38/f_S$ | | s | |
| FILTER CHARACTERISTICS-2: SLOW ROLLOFF | | | | | | |
| Pass band | $\pm 0.001\text{ dB}$ | | | $0.21 f_S$ | | |
| | -3 dB | | | $0.448 f_S$ | | |
| Stop band | | $0.79 f_S$ | | | | |
| Pass-band ripple | | | | ± 0.001 | dB | |
| Stop-band attenuation | Stop band = $0.732 f_S$ | -80 | | | dB | |
| Delay time | | | $38/f_S$ | | s | |
| POWER SUPPLY REQUIREMENTS | | | | | | |
| V_{DD} | Voltage range | | 3 | 3.3 | 3.6 | VDC |
| V_{CC1} | | | | | | |
| V_{CC2L} | | | 4.75 | 5 | 5.25 | VDC |
| V_{CC2R} | | | | | | |
| I_{DD} | Supply current (1) | $f_S = 44.1\text{ kHz}$ | | 7 | 9 | mA |
| | | $f_S = 96\text{ kHz}$ | | 13 | | |
| | | $f_S = 192\text{ kHz}$ | | 25 | | |
| I_{CC} | | $f_S = 44.1\text{ kHz}$ | | 18 | 23 | mA |
| | | $f_S = 96\text{ kHz}$ | | 19 | | |
| | | $f_S = 192\text{ kHz}$ | | 20 | | |
| Power dissipation (1) | $f_S = 44.1\text{ kHz}$ | | 115 | 150 | mW | |
| | $f_S = 96\text{ kHz}$ | | 140 | | | |
| | $f_S = 192\text{ kHz}$ | | 180 | | | |
| TEMPERATURE RANGE | | | | | | |
| Operation temperature | | -25 | | 85 | $^\circ\text{C}$ | |
| θ_{JA} Thermal resistance | 28-pin SSOP | | 100 | | $^\circ\text{C/W}$ | |

(1) Input is BPZ data.

PIN ASSIGNMENTS

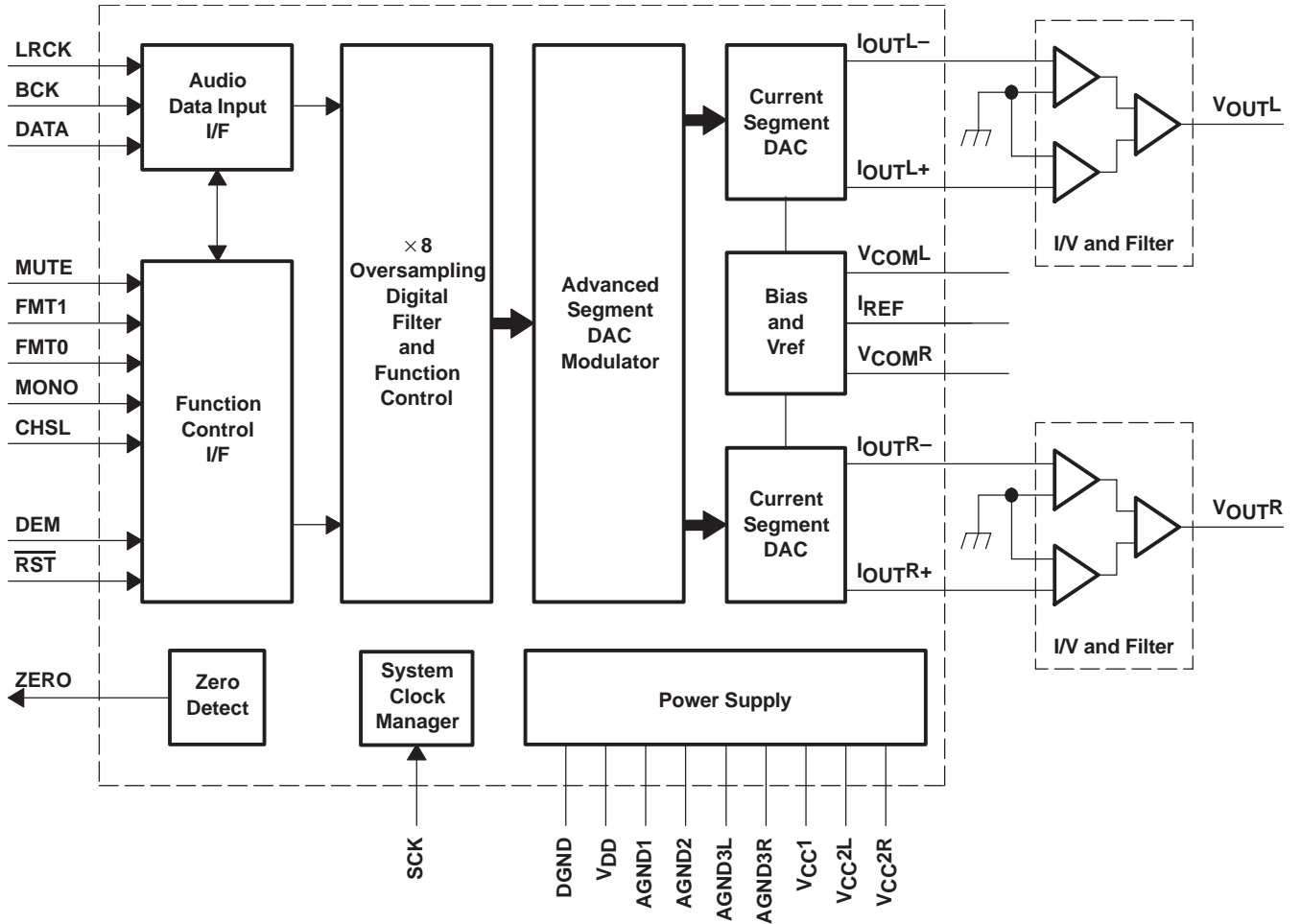


Terminal Functions

| 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 (1) |
| CHSL | 2 | I | L-, R-channel select (1) |
| DATA | 5 | I | Serial audio data input (1) |
| DEM | 3 | I | De-emphasis enable (1) |
| DGND | 8 | – | Digital ground |
| FMT0 | 11 | I | Audio data format select (1) |
| FMT1 | 12 | I | Audio data format select (1) |
| I _{OUTL+} | 25 | O | L-channel analog current output + |
| I _{OUTL-} | 26 | O | L-channel analog current output – |
| I _{OUTR+} | 17 | O | R-channel analog current output + |
| I _{OUTR-} | 18 | O | R-channel analog current output – |
| I _{REF} | 20 | – | Output current reference bias pin |
| LRCK | 4 | I | Left and right clock (f _S) input (1) |
| MONO | 1 | I | Monaural mode enable (1) |
| MUTE | 10 | I | Mute control (1) |
| $\overline{\text{RST}}$ | 14 | I | Reset(1) |
| SCK | 7 | I | System clock input(1) |
| V _{CC1} | 23 | – | Analog power supply, 5 V |
| V _{CC2L} | 28 | – | Analog power supply (L-channel DACFF), 5 V |
| V _{CC2R} | 15 | – | Analog power supply (R-channel DACFF), 5 V |
| V _{COML} | 22 | – | L-channel internal bias decoupling pin |
| V _{COMR} | 21 | – | R-channel internal bias decoupling pin |
| V _{DD} | 9 | – | Digital power supply, 3.3 V |
| ZERO | 13 | O | Zero flag |

(1) Schmitt-trigger input, 5-V tolerant

FUNCTIONAL BLOCK DIAGRAM



TYPICAL PERFORMANCE CURVES

DIGITAL FILTER

Digital Filter Response

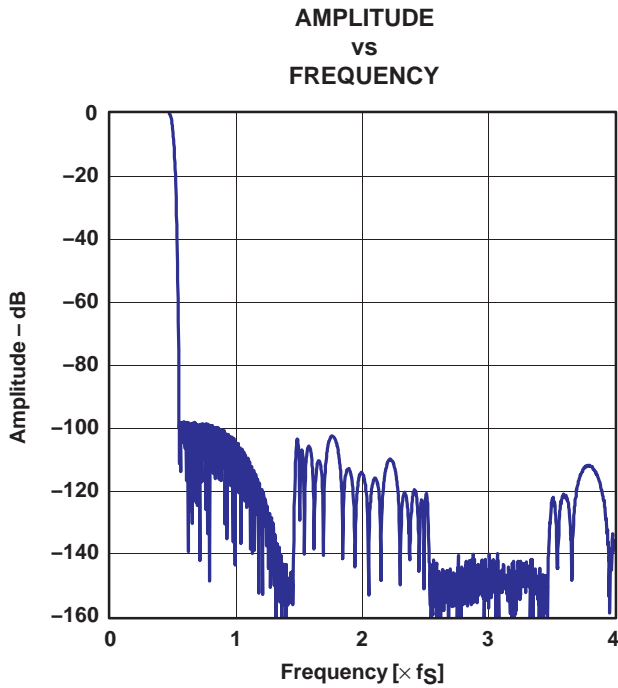


Figure 1. Frequency Response, Sharp Rolloff

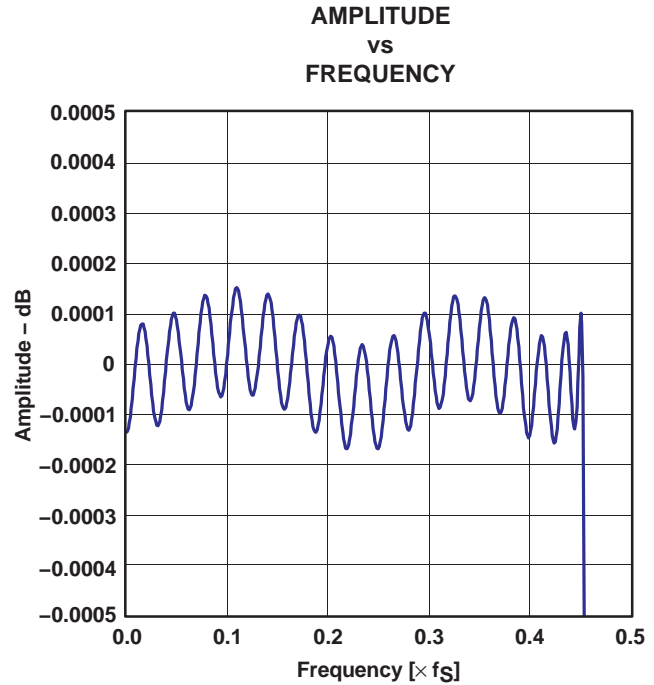


Figure 2. Pass-Band Ripple, Sharp Rolloff

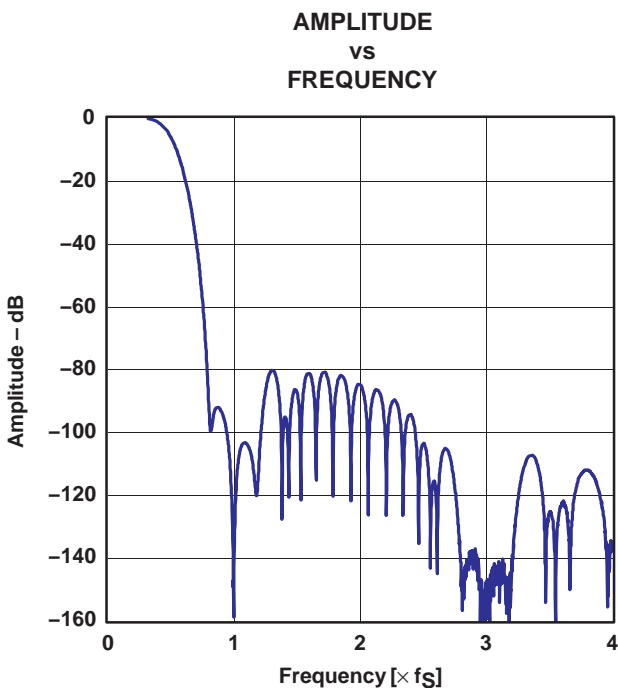


Figure 3. Frequency Response, Slow Rolloff

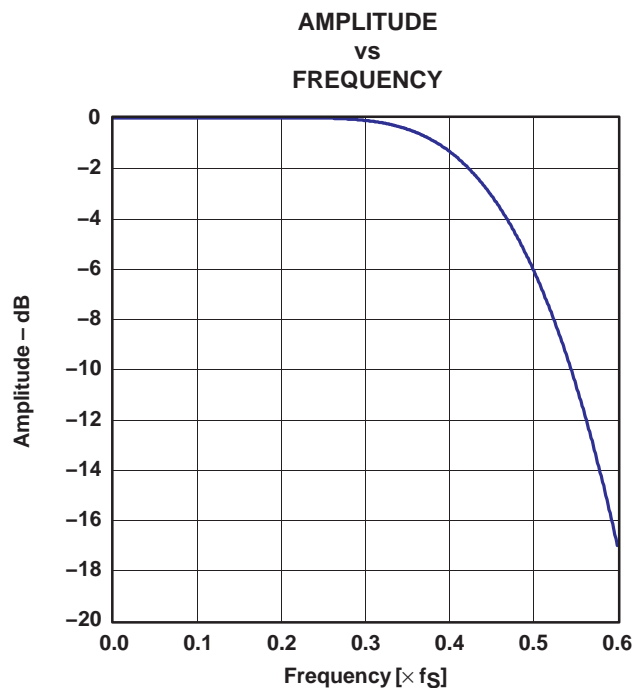


Figure 4. Transition Characteristics, Slow Rolloff

De-Emphasis Filter

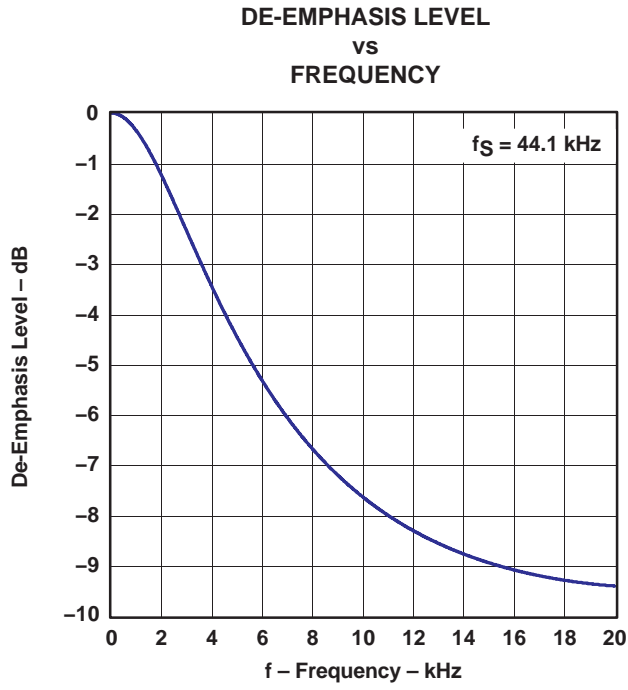


Figure 5

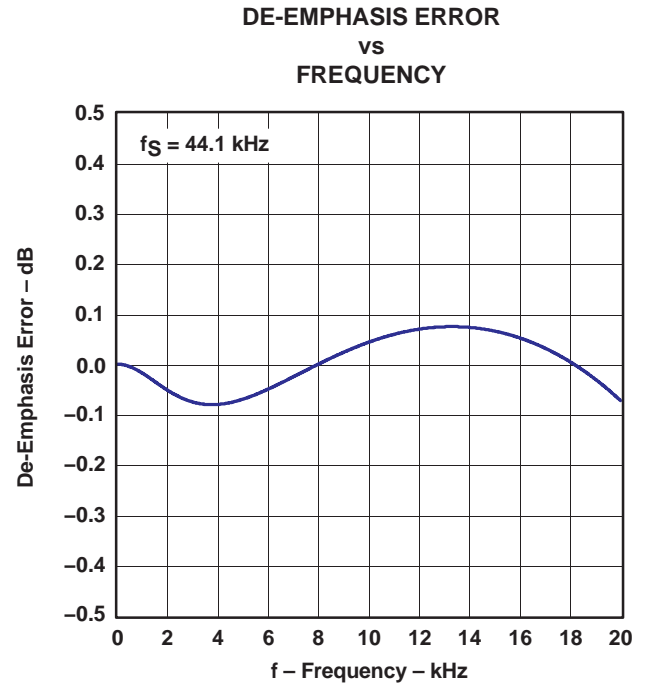


Figure 6

ANALOG DYNAMIC PERFORMANCE

Supply Voltage Characteristics

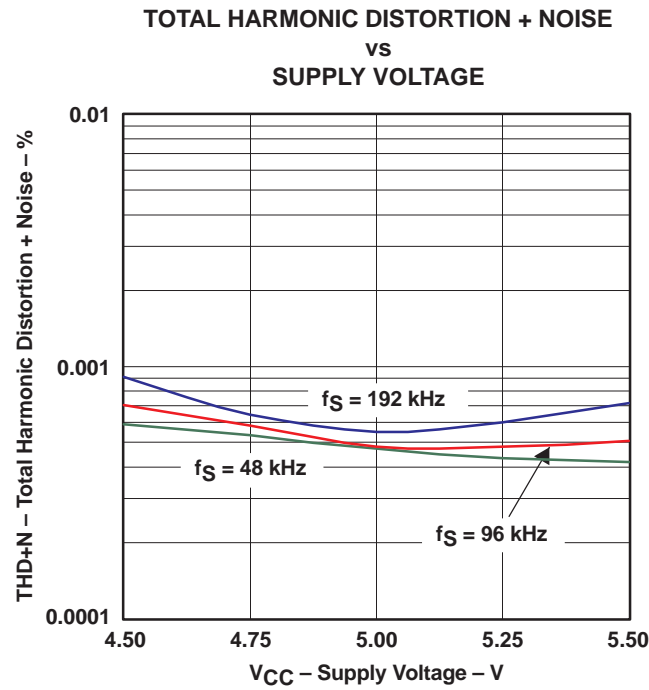


Figure 7

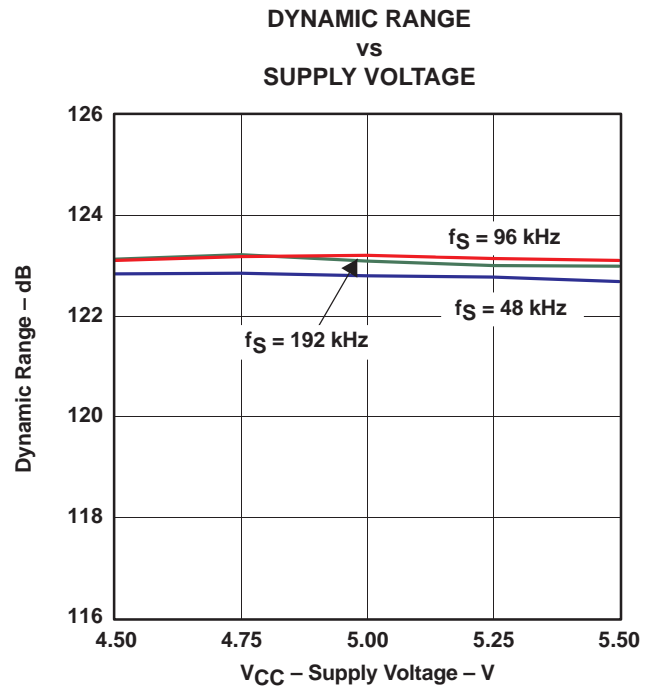


Figure 8

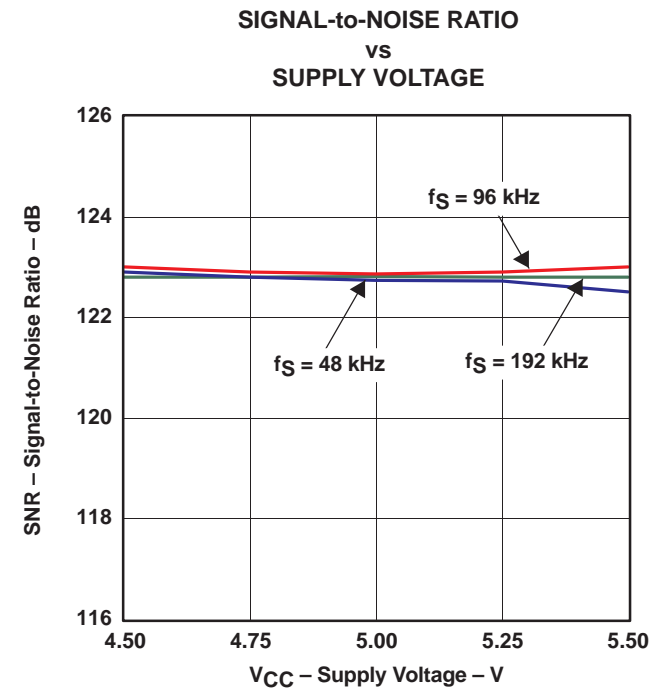


Figure 9

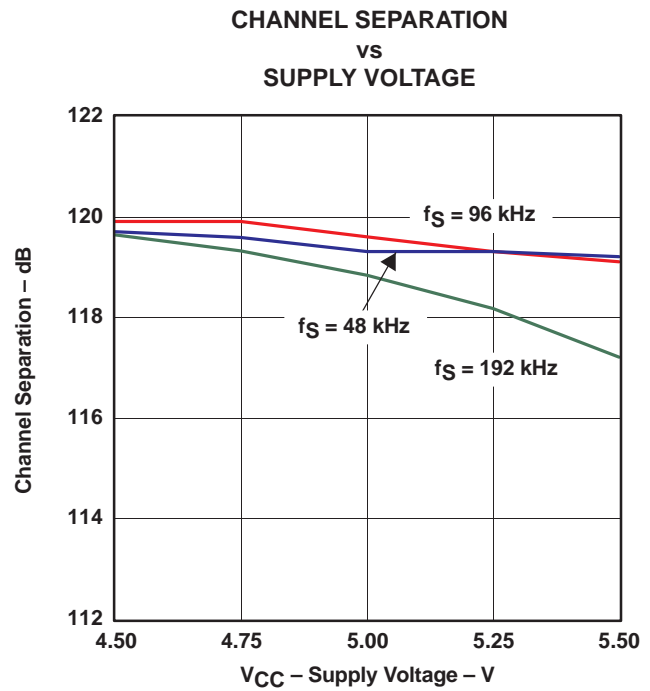


Figure 10

NOTE: PCM mode, T_A = 25°C, V_{DD} = 3.3 V, measurement circuit is Figure 24.

Temperature Characteristics

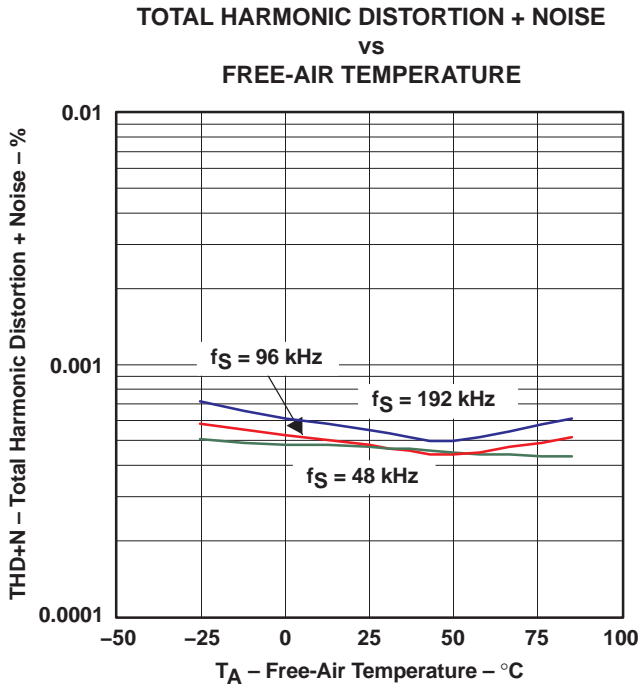


Figure 11

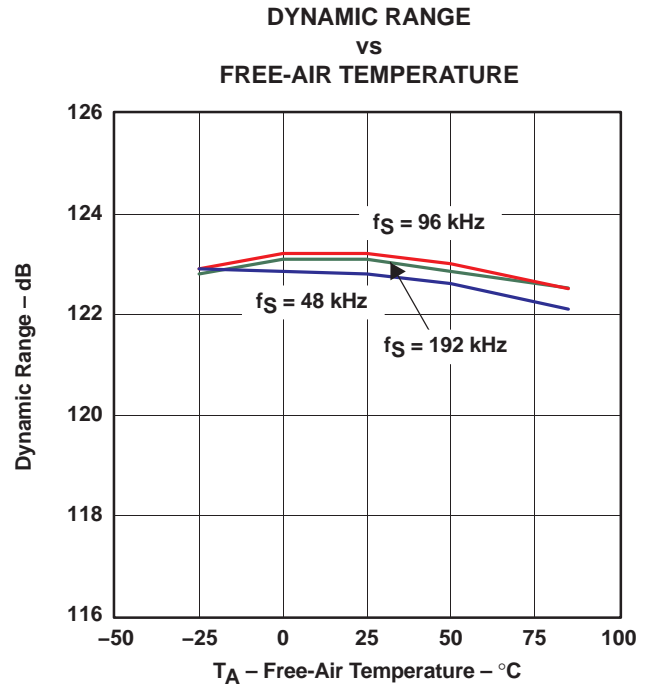


Figure 12

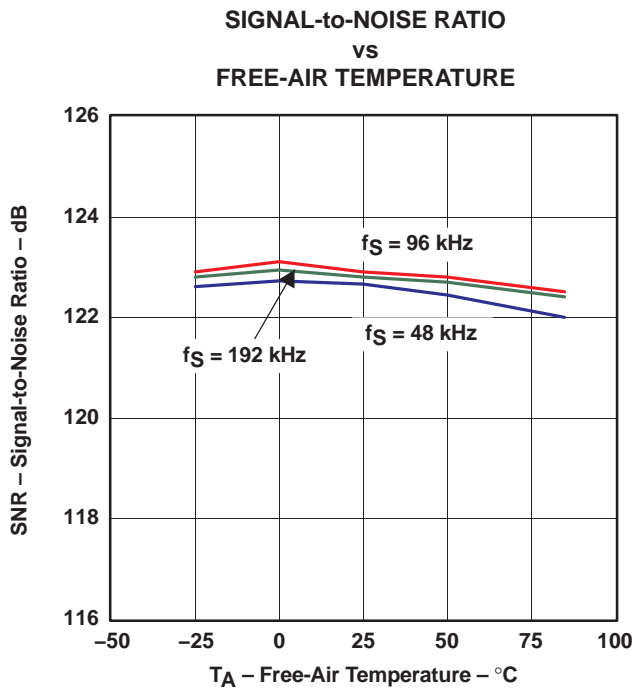


Figure 13

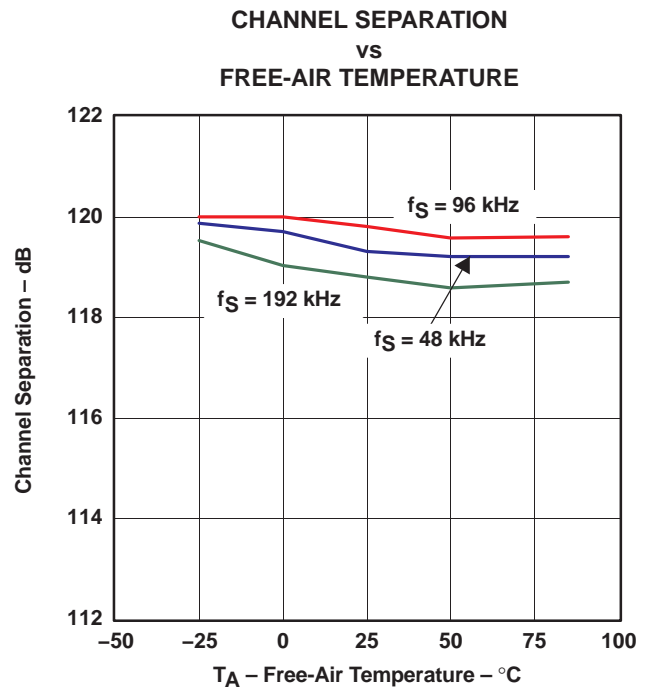
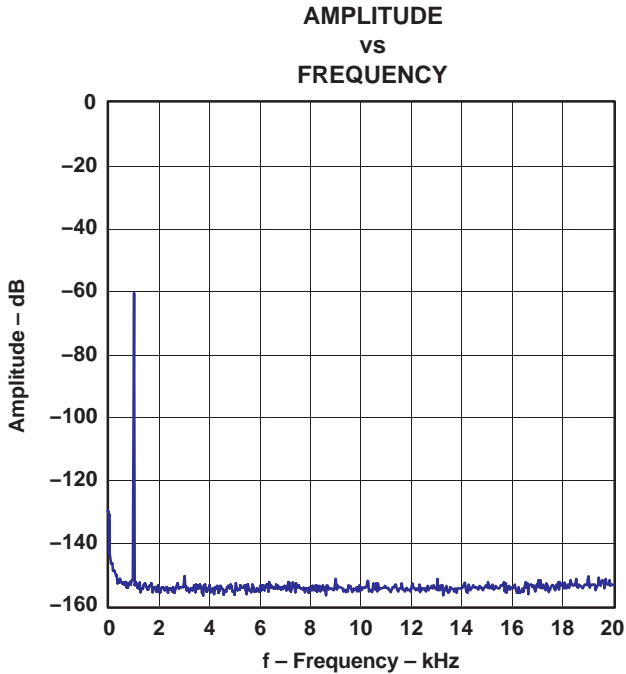
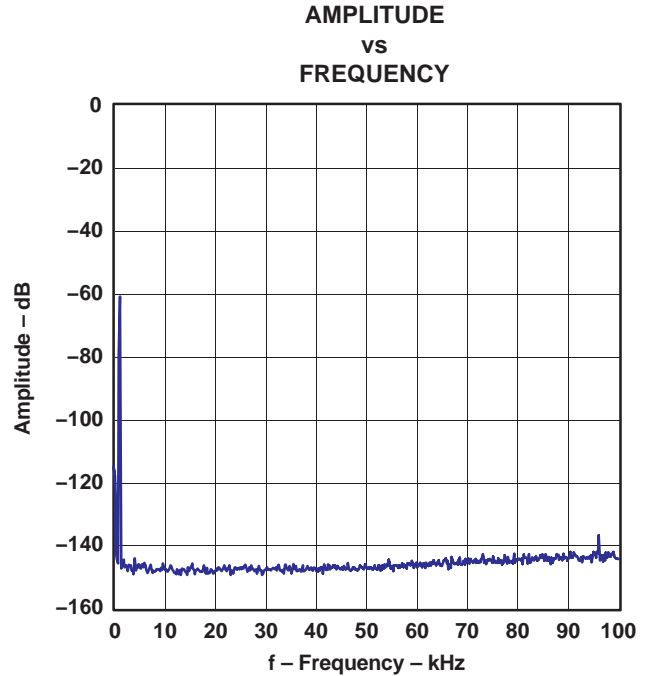


Figure 14

NOTE: PCM mode, V_{DD} = 3.3 V, V_{CC} = 5 V, measurement circuit is Figure 24.



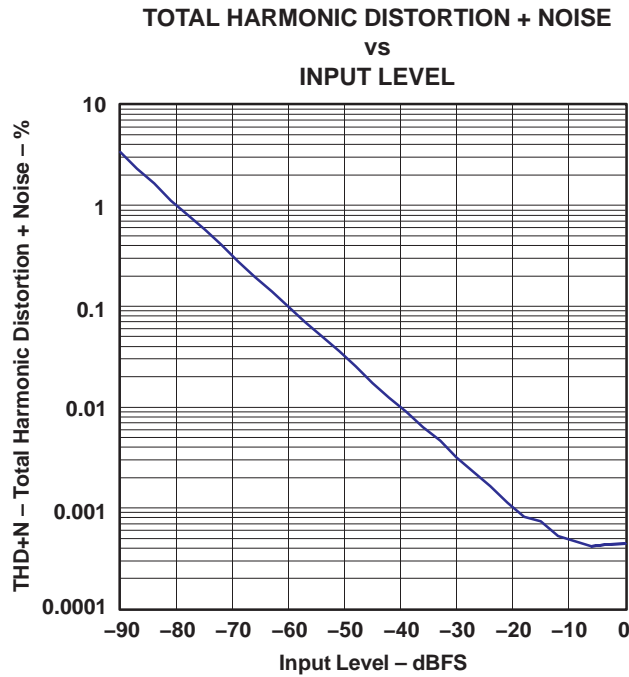
NOTE: $f_S = 48$ kHz, 32768 point 8 average, $T_A = 25^\circ\text{C}$, $V_{DD} = 3.3$ V, $V_{CC} = 5$ V, measurement circuit is Figure 24.



NOTE: $f_S = 96$ kHz, 32768 point 8 average, $T_A = 25^\circ\text{C}$, $V_{DD} = 3.3$ V, $V_{CC} = 5$ V, measurement circuit is Figure 24.

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

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 24.

Figure 17. THD+N vs Input Level, PCM Mode

SYSTEM CLOCK AND RESET FUNCTIONS

System Clock Input

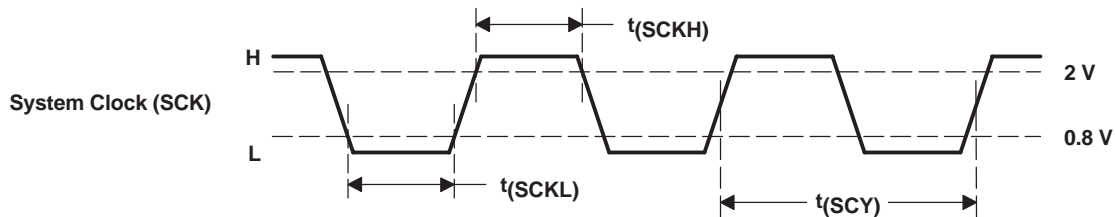
The PCM1798 requires a system clock for operating the digital interpolation filters and advanced segment DAC modulators. The system clock is applied at the SCK input (pin 7). The PCM1798 has a system clock detection circuit that automatically senses the frequency at which the system clock is operating. 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 PCM1798 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 PCM1798 includes a power-on reset function. Figure 19 shows the operation of this function. With $V_{DD} > 2\text{ V}$, the power-on reset function is enabled. The initialization sequence requires 1024 system clocks from the time $V_{DD} > 2\text{ V}$.

The PCM1798 also includes an external reset capability using the $\overline{\text{RST}}$ input (pin 14). This allows an external controller or master reset circuit to force the PCM1798 to initialize to its default reset state.

Figure 20 shows the external reset operation and timing. The $\overline{\text{RST}}$ pin is set to logic 0 for a minimum of 20 ns. The $\overline{\text{RST}}$ 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 PCM1798 power up and system clock activation.

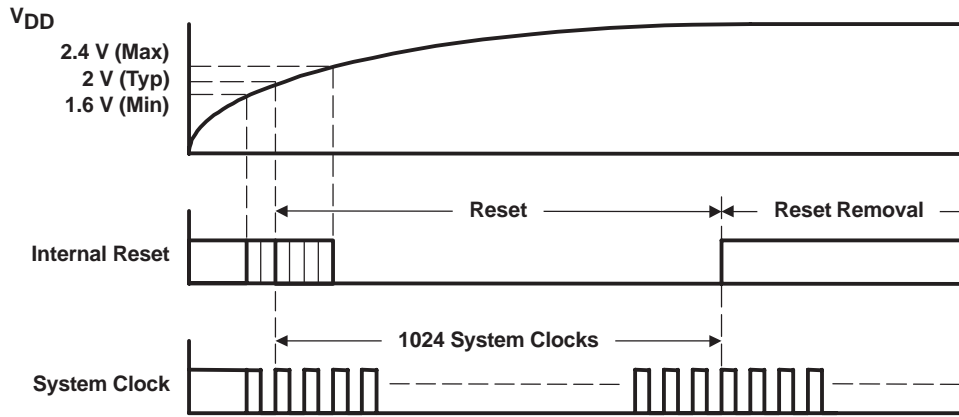
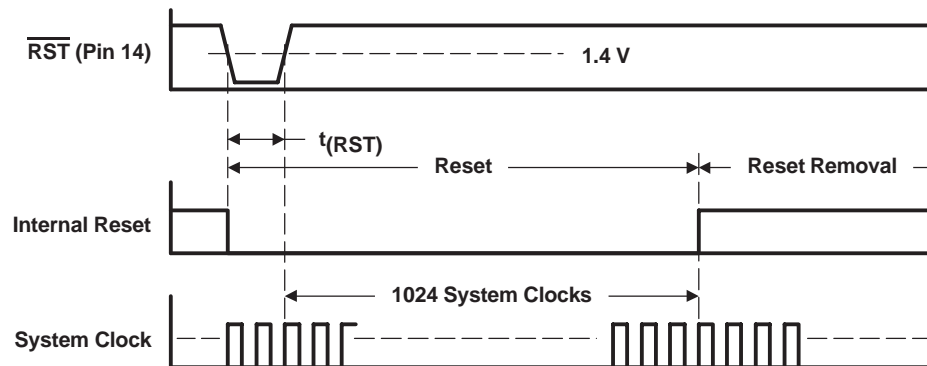


Figure 19. Power-On Reset Timing



| PARAMETERS | | MIN | MAX | UNITS |
|-----------------|---------------------------|-----|-----|-------|
| $t(\text{RST})$ | Reset pulse duration, LOW | 20 | | ns |

Figure 20. External Reset Timing

AUDIO DATA INTERFACE

Audio Serial Interface

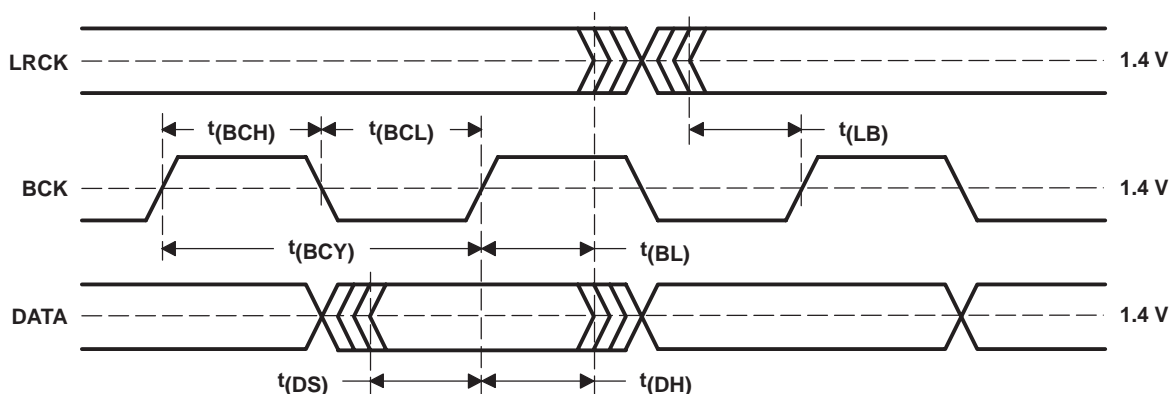
The audio interface port is a 3-wire serial port. It includes LRCK (pin 4), BCK (pin 6), and DATA (pin 5). BCK is the serial audio bit clock, and it is used to clock the serial data present on DATA into the serial shift register of the audio interface. Serial data is clocked into the PCM1798 on the rising edge of BCK. LRCK is the serial audio left/right word clock.

The PCM1798 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 ± 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

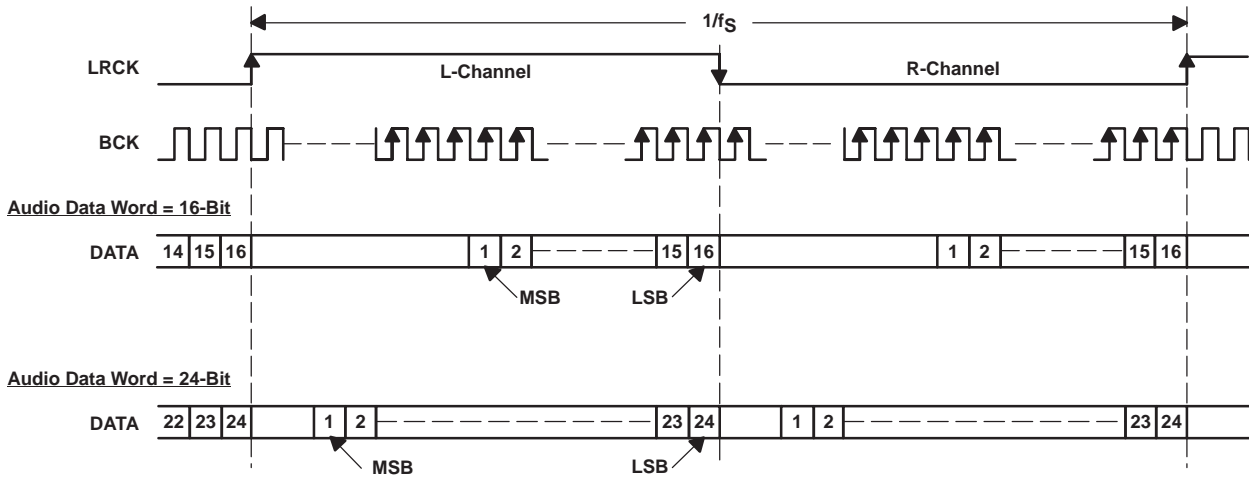
The PCM1798 supports industry-standard audio data formats, including standard right-justified, I²S, and left-justified. The data formats are shown in Figure 22. Data formats are selected using FMT0 (pin 11) and FMT1 (pin 12) as shown in Table 2. All formats require binary two's-complement, MSB-first audio data. Figure 21 shows a detailed timing diagram for the serial audio interface.



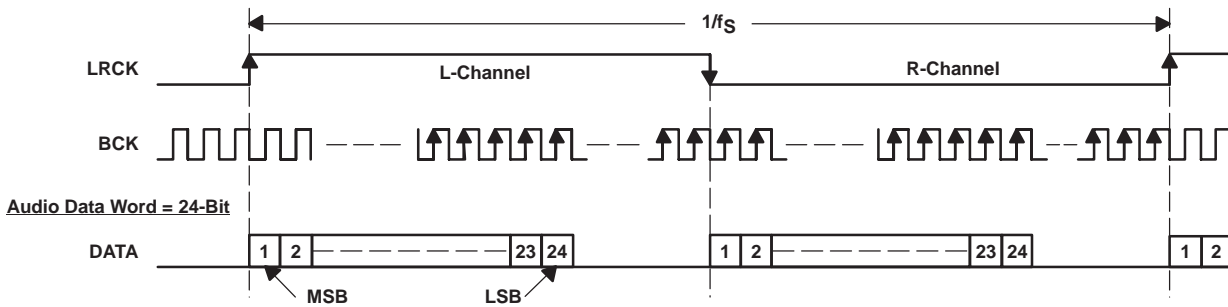
| PARAMETERS | | MIN | MAX | UNITS |
|------------|------------------------------|------------------------|-----|-------|
| $t(BCY)$ | BCK pulse cycle time | 70 | | ns |
| $t(BCL)$ | BCK pulse duration, LOW | 30 | | ns |
| $t(BCH)$ | BCK pulse duration, HIGH | 30 | | ns |
| $t(BL)$ | BCK rising edge 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 data | 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) I²S Data Format; L-Channel = LOW, R-Channel = HIGH

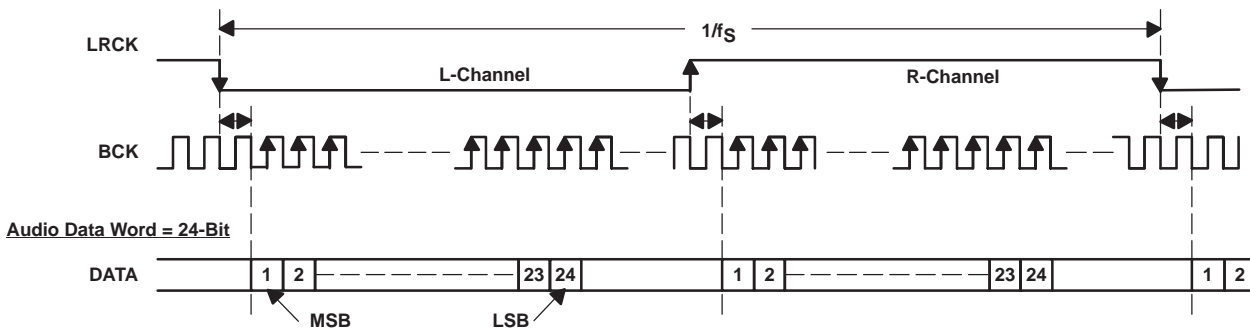


Figure 22. Audio Data Input Formats

FUNCTION DESCRIPTIONS

Audio data format

Audio format is selected using FMT0 (pin 11) and FMT1 (pin 12). The PCM1798 also supports monaural mode and DF bypass mode using MONO (pin 1) and CHSL (pin 2). The PCM1798 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 ² 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 ² 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 ² 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 ² 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 PCM1798 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 PCM1798 has a de-emphasis filter for the sampling frequency of 44.1 kHz. The de-emphasis filter is controlled using DEM (pin 3).

Zero Detection

When the PCM1798 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 PCM1798 sets ZERO (pin 13) to HIGH.

APPLICATION INFORMATION

TYPICAL CONNECTION DIAGRAM

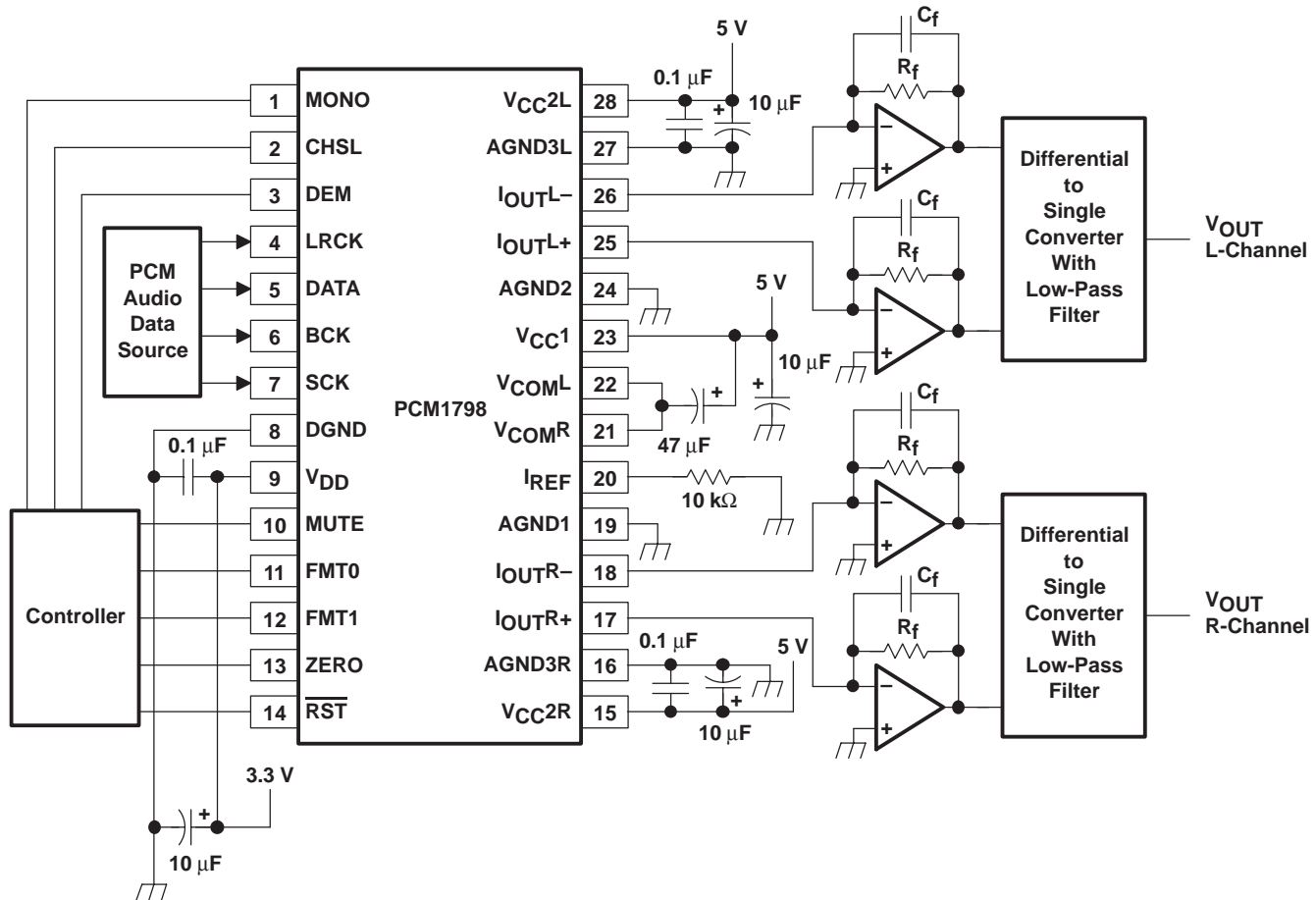


Figure 23. Typical Application Circuit

APPLICATION CIRCUIT

The design of the application circuit is very important in order to actually realize the high S/N ratio of which the PCM1798 is capable. This is because noise and distortion that are generated in an application circuit are not negligible.

In the third-order LPF circuit of Figure 24, the output level is 2.1 V RMS, and 123 dB S/N is achieved.

I/V Section

The current of the PCM1798 on each of the output pins (I_{OUTL+} , I_{OUTL-} , I_{OUTR+} , I_{OUTR-}) is 4 mA p-p at 0 dB (full scale). The voltage output level of the I/V converter (V_i) is given by following equation:

$$V_i = 4 \text{ mA p-p} \times R_f \text{ (} R_f \text{ : feedback resistance of I/V converter)}$$

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 PCM1798 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 low-noise type.

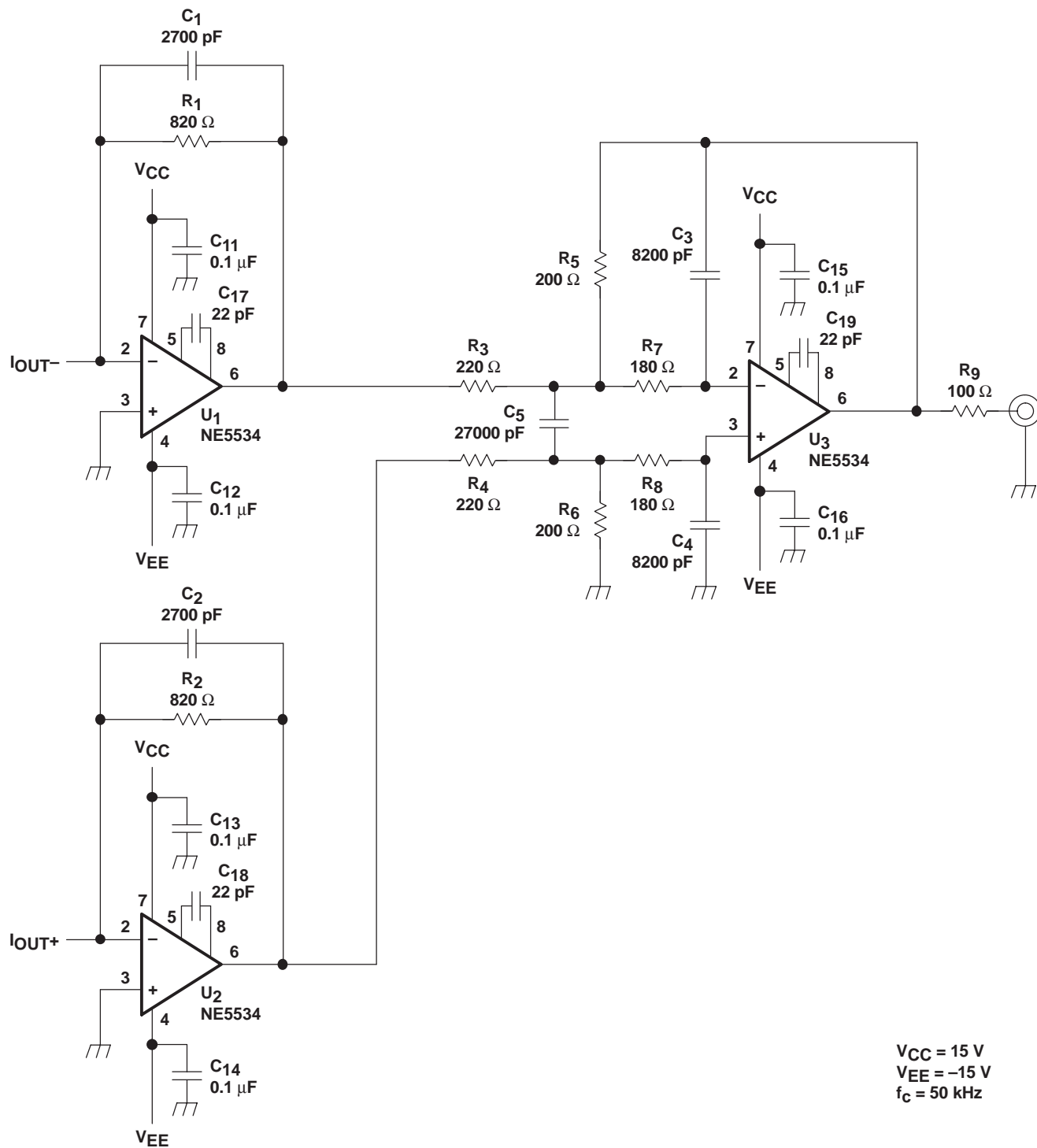


Figure 24. Measurement Circuit

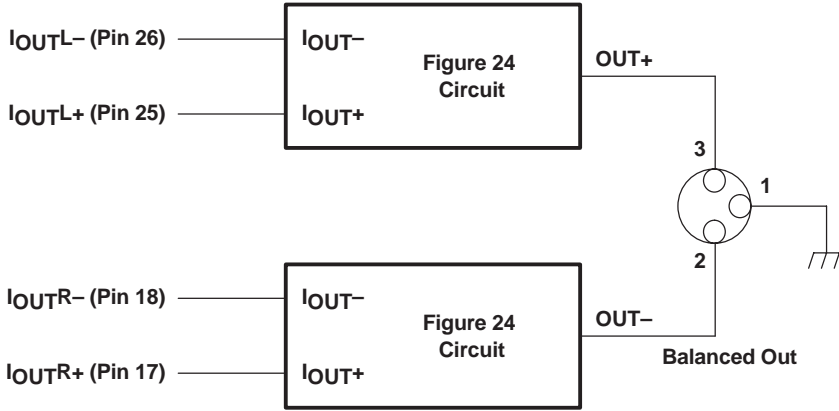


Figure 25. Measurement Circuit for Monaural Mode

APPLICATION FOR EXTERNAL DIGITAL FILTER INTERFACE

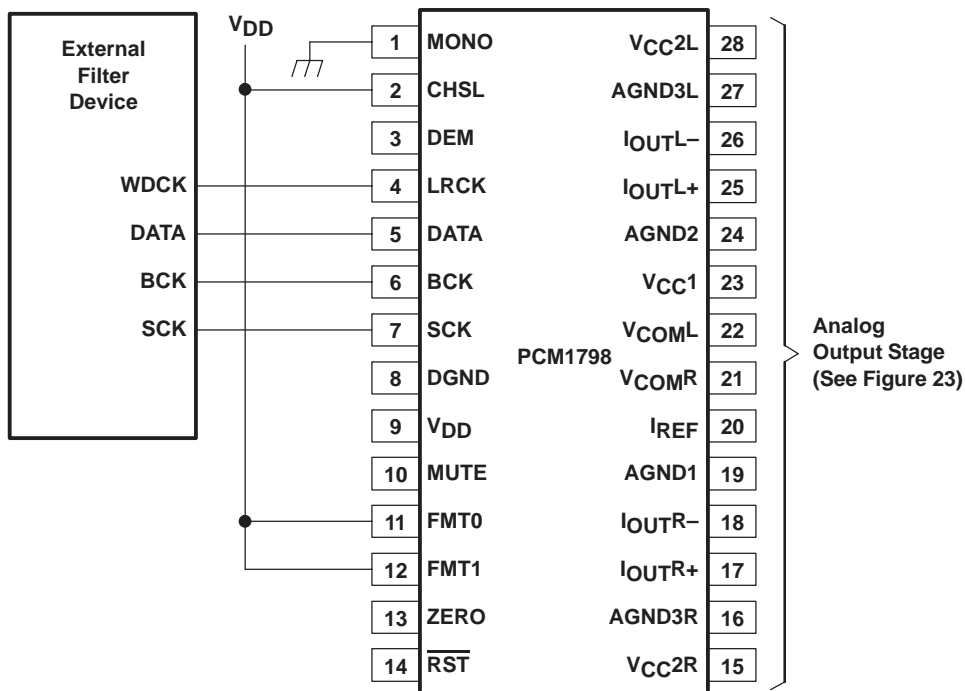


Figure 26. Connection Diagram for External Digital Filter (Internal DF Bypass Mode) Application

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 26. The word clock (WDCK) must be operated at $8\times$ or $4\times$ the desired sampling frequency, f_s .

Pin Assignment When Using the External Digital Filter Interface

- LRCK (pin 4): WDCK as word clock input
- DATA (pin 5): Monaural audio data input
- BCK (pin 6): Bit clock input

Audio Format

The PCM1798 in the external digital filter interface mode supports the 24-bit right-justified audio format as shown in Figure 27.

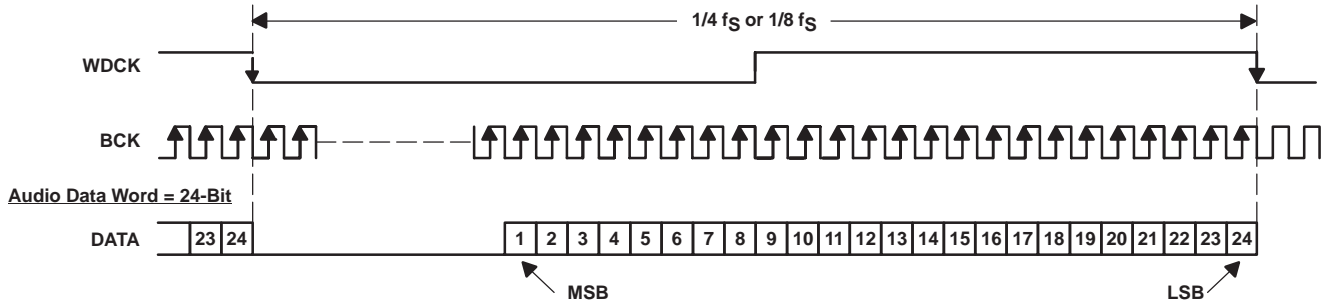
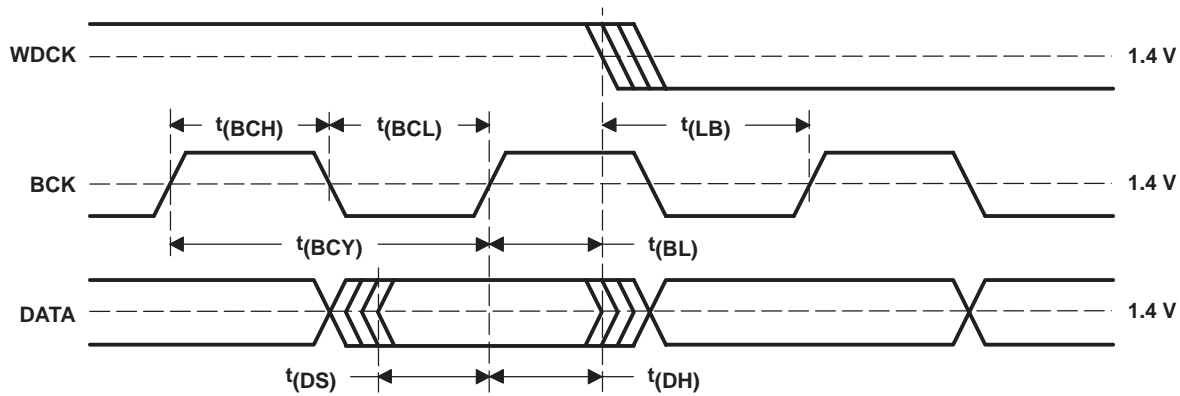


Figure 27. Audio Data Input Format for External Digital Filter (Internal DF Bypass Mode) Application

System Clock (SCK) and Interface Timing

The PCM1798 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 28.



| 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 28. Audio Interface Timing for External Digital Filter (Internal DF Bypass Mode) Application

ANALOG OUTPUT

Table 3 and Figure 29 show the relationship between the digital input code and analog output.

Table 3. Analog Output Current and Voltage

| | 800000 (-FS) | 000000 (BPZ) | 7FFFFFFF (+FS) |
|-----------------|--------------|--------------|----------------|
| I_{OUTN} [mA] | -1.5 | -3.5 | -5.5 |
| I_{OUTP} [mA] | -5.5 | -3.5 | -1.5 |
| V_{OUTN} [V] | -1.23 | -2.87 | -4.51 |
| V_{OUTP} [V] | -4.51 | -2.87 | -1.23 |
| V_{OUT} [V] | -2.98 | 0 | 2.98 |

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.

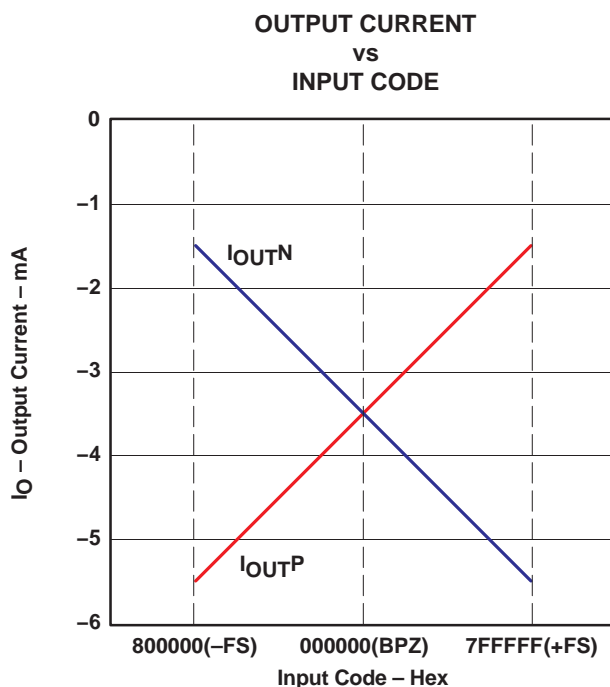


Figure 29. The Relationship Between Digital Input and Analog Output

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| PCM1798DB | ACTIVE | SSOP | DB | 28 | 47 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| PCM1798DBG4 | ACTIVE | SSOP | DB | 28 | 47 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| PCM1798DBR | ACTIVE | SSOP | DB | 28 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| PCM1798DBRG4 | ACTIVE | SSOP | DB | 28 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |

⁽¹⁾ 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.

⁽²⁾ 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)

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

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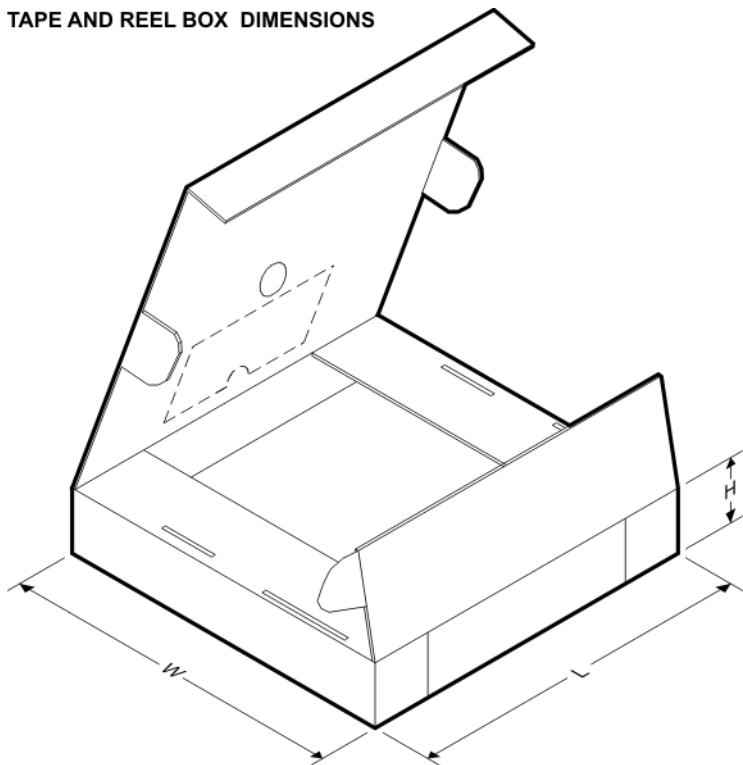
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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 |
|------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| PCM1798DBR | 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) |
|------------|--------------|-----------------|------|------|-------------|------------|-------------|
| PCM1798DBR | 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

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