



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

FEATURES

- 24-Bit Resolution
- Analog Performance:
 - Dynamic Range: 113 dB
 - THD+N: 0.001%
 - Full-Scale Output: 2.1 V rms (at Postamplifier)
- Differential Voltage Output: 3.2 V p-p
- 8× Oversampling Digital Filter:
 - Stop-Band Attenuation: –82 dB
 - Pass-Band Ripple: ±0.002 dB
- Sampling Frequency: 10 kHz to 200 kHz
- System Clock: 128, 192, 256, 384, 512, or 768 f_S With Autodetect
- Accepts 16-, 20-, and 24-Bit Audio Data
- Data Formats: Standard, I²S, and Left-Justified
- Digital De-Emphasis
- Soft Mute
- Zero Flags for Each Output
- Dual Supply Operation:
 - 5-V Analog, 3.3-V Digital

- 5-V Tolerant Digital Inputs
- Small 28-Lead SSOP Package, Lead-Free Product

APPLICATIONS

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

DESCRIPTION

The PCM1793 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 PCM1793 provides balanced voltage 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 |
|-----------|--------------|--------------|-----------------------------|-----------------|-----------------|-----------------|
| PCM1793DB | 28-lead SSOP | 28DB | –25°C to 85°C | PCM1793 | PCM1793DB | Tube |
| | | | | | PCM1793DBR | Tape and reel |

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

| | | PCM1793 |
|---|---|---|
| Supply voltage | V _{CCF} , V _{CCL} , V _{CCC} , V _{CCR} | –0.3 V to 6.5 V |
| | V _{DD} | –0.3 V to 4 V |
| Supply voltage differences: V _{CCF} , V _{CCL} , V _{CCC} , V _{CCR} | | ±0.1 V |
| Ground voltage differences: AGNDF, AGNDL, AGNDC, AGNDR, DGND | | ±0.1 V |
| Digital input voltage | LRCK, DATA, BCK, SCK, DEMP0, DEMP1, FMT0, FMT1, FMT2, RST, MUTE | –0.3 V to 6.5 V |
| | ZEROL, ZEROR | –0.3 V to (V _{DD} + 0.3 V) < 4 V |
| Analog input voltage | | –0.3 V to (V _{CC} + 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) | | 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 CHARACTERISTICSall specifications at T_A = 25°C, V_{CC} = 5 V, V_{DD} = 3.3 V, f_S = 44.1 kHz, system clock = 256 f_S, and 24-bit data, unless otherwise noted

| PARAMETER | TEST CONDITIONS | PCM1793DB | | | UNIT |
|-----------------------------|-----------------------------|-----------------------------------|---|-----|------|
| | | MIN | TYP | MAX | |
| RESOLUTION | | | 24 | | Bits |
| DATA FORMAT | | | | | |
| | Audio data interface format | | Standard, I ² S, left justified | | |
| | Audio data bit length | | 16-, 20-, 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 V | –10 | | |
| V _{OH} | Output logic level | I _{OH} = –2 mA | 2.4 | | VDC |
| V _{OL} | | I _{OL} = 2 mA | 0.4 | | |

ELECTRICAL CHARACTERISTICS (Continued)

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

| PARAMETER | TEST CONDITIONS | PCM1793DB | | | UNIT |
|-----------------------------------|---|-------------|-------------|--------|------------|
| | | MIN | TYP | MAX | |
| DYNAMIC PERFORMANCE (1) | | | | | |
| THD+N at $V_{OUT} = 0\text{ dB}$ | $f_S = 44.1\text{ kHz}$ | | 0.001% | 0.002% | |
| | $f_S = 96\text{ kHz}$ | | 0.0015% | | |
| | $f_S = 192\text{ kHz}$ | | 0.003% | | |
| Dynamic range | EIAJ, A-weighted, $f_S = 44.1\text{ kHz}$ | 110 | 113 | | dB |
| | EIAJ, A-weighted, $f_S = 96\text{ kHz}$ | | 113 | | |
| | EIAJ, A-weighted, $f_S = 192\text{ kHz}$ | | 113 | | |
| Signal-to-noise ratio | EIAJ, A-weighted, $f_S = 44.1\text{ kHz}$ | 110 | 113 | | dB |
| | EIAJ, A-weighted, $f_S = 96\text{ kHz}$ | | 113 | | |
| | EIAJ, A-weighted, $f_S = 192\text{ kHz}$ | | 113 | | |
| Channel separation | $f_S = 44.1\text{ kHz}$ | 106 | 110 | | dB |
| | $f_S = 96\text{ kHz}$ | | 110 | | |
| | $f_S = 192\text{ kHz}$ | | 109 | | |
| Level linearity error | $V_{OUT} = -120\text{ dB}$ | | ± 1 | | dB |
| ANALOG OUTPUT | | | | | |
| Gain error | | -8 | ± 3 | 8 | % of FSR |
| Gain mismatch, channel-to-channel | | -3 | ± 0.5 | 3 | % of FSR |
| Bipolar zero error | At BPZ | -2 | ± 0.5 | 2 | % of FSR |
| Differential output voltage (2) | Full scale (0 dB) | | 3.2 | | V p-p |
| Bipolar zero voltage (2) | At BPZ | | 1.4 | | V |
| Load impedance (2) | $R_1 = R_2$ | 1.7 | | | k Ω |
| DIGITAL FILTER PERFORMANCE | | | | | |
| De-emphasis error | | | ± 0.1 | | dB |
| Pass band | $\pm 0.002\text{ dB}$ | | $0.454 f_S$ | | |
| | -3 dB | | $0.49 f_S$ | | |
| Stop band | | $0.546 f_S$ | | | |
| Pass-band ripple | | | ± 0.002 | | dB |
| Stop-band attenuation | Stop band = $0.546 f_S$ | -75 | | | dB |
| | Stop band = $0.567 f_S$ | -82 | | | dB |
| Delay time | | $29/f_S$ | | | s |

(1) Dynamic performance and DC accuracy are specified at the output of the postamplifier as shown in Figure 28. Analog performance specifications are measured using the System Two™ Cascade audio measurement system by Audio Precision™ in the averaging mode. At all sampling frequency operations, measurement bandwidth is limited with a 20-kHz AES17 filter.

(2) These parameters are defined at the PCM1793 output pin. Load impedance, R1 and R2, are input resistors of the postamplifier. These are defined as dc loads.

ELECTRICAL CHARACTERISTICS (Continued)

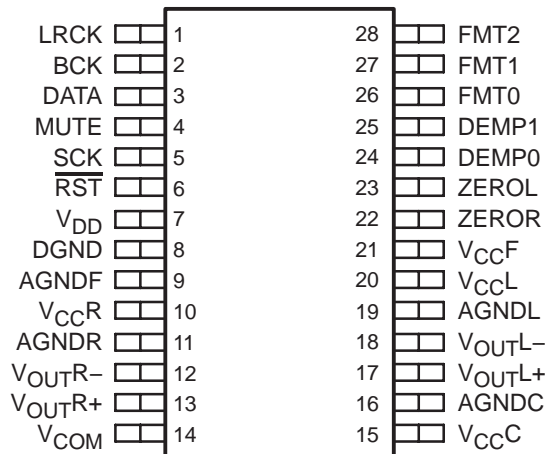
all specifications at $T_A = 25^\circ\text{C}$, $V_{CC} = 5\text{ V}$, $V_{DD} = 3.3\text{ V}$, $f_S = 44.1\text{ kHz}$, system clock = $256 f_S$, and 24-bit data, unless otherwise noted

| PARAMETER | TEST CONDITIONS | PCM1793DB | | | UNIT | |
|----------------------------------|--------------------|-------------------------|-----|------|------|--------------------|
| | | MIN | TYP | MAX | | |
| POWER SUPPLY REQUIREMENTS | | | | | | |
| V_{DD} | Voltage range | | 3 | 3.3 | 3.6 | VDC |
| V_{CC} | | | 4.5 | 5 | 5.5 | |
| I_{DD} | Supply current (1) | $f_S = 44.1\text{ kHz}$ | | 6.5 | 8 | mA |
| | | $f_S = 96\text{ kHz}$ | | 13.5 | | |
| | | $f_S = 192\text{ kHz}$ | | 28 | | |
| I_{CC} | Supply current (1) | $f_S = 44.1\text{ kHz}$ | | 14 | 16 | mA |
| | | $f_S = 96\text{ kHz}$ | | 15 | | |
| | | $f_S = 192\text{ kHz}$ | | 16 | | |
| Power dissipation (1) | | $f_S = 44.1\text{ kHz}$ | | 90 | 110 | mW |
| | | $f_S = 96\text{ kHz}$ | | 120 | | |
| | | $f_S = 192\text{ kHz}$ | | 170 | | |
| 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

PCM1793
(TOP VIEW)

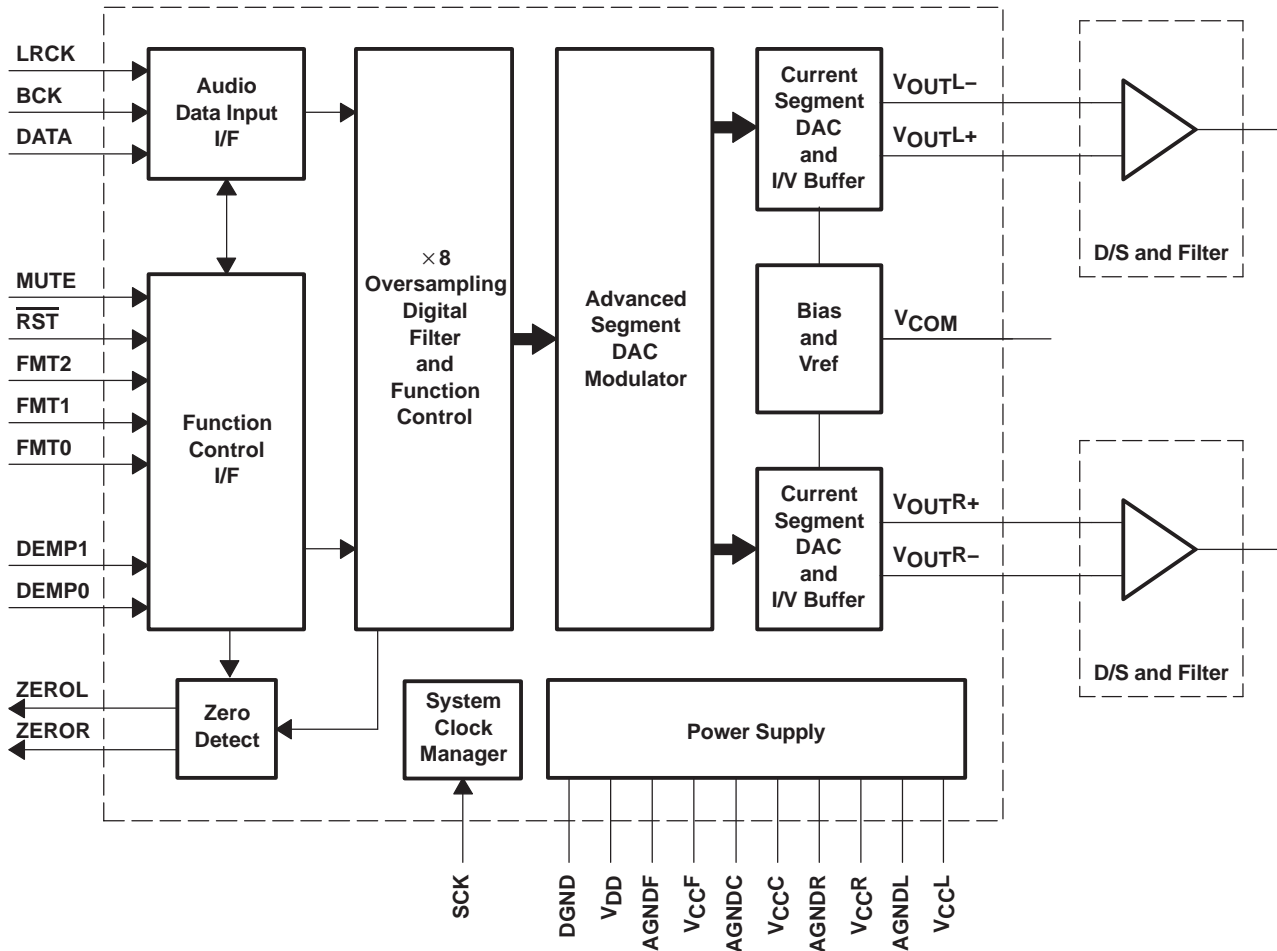


Terminal Functions

| TERMINAL | | I/O | DESCRIPTIONS |
|-------------------------|-----|-----|---|
| NAME | PIN | | |
| AGNDC | 16 | – | Analog ground (internal bias and current DAC) |
| AGNDF | 9 | – | Analog ground (DACFF) |
| AGNDL | 19 | – | Analog ground (L-channel I/V) |
| AGNDR | 11 | – | Analog ground (R-channel I/V) |
| BCK | 2 | I | Bit clock input ⁽¹⁾ |
| DATA | 3 | I | Serial audio data input ⁽¹⁾ |
| DEMP0 | 24 | I | De-emphasis control 0 ⁽¹⁾ |
| DEMP1 | 25 | I | De-emphasis control 1 ⁽¹⁾ |
| DGND | 8 | – | Digital ground |
| FMT0 | 26 | I | Audio data format select 0 ⁽¹⁾ |
| FMT1 | 27 | I | Audio data format select 1 ⁽¹⁾ |
| FMT2 | 28 | I | Audio data format select 2 ⁽¹⁾ |
| LRCK | 1 | I | Left and right clock (f _S) input ⁽¹⁾ |
| MUTE | 4 | I | Analog output mute control ⁽¹⁾ |
| $\overline{\text{RST}}$ | 6 | I | Reset ⁽¹⁾ |
| SCK | 5 | I | System clock input ⁽¹⁾ |
| V _{CC} C | 15 | – | Analog power supply (internal bias and current DAC), 5 V |
| V _{CC} F | 21 | – | Analog power supply (DACFF), 5 V |
| V _{CC} L | 20 | – | Analog power supply (L-channel I/V), 5 V |
| V _{CC} R | 10 | – | Analog power supply (R-channel I/V), 5 V |
| V _{COM} | 14 | – | Internal bias decoupling pin |
| V _{DD} | 7 | – | Digital power supply, 3.3 V |
| V _{OUT} L+ | 17 | O | L-channel analog voltage output + |
| V _{OUT} L– | 18 | O | L-channel analog voltage output – |
| V _{OUT} R+ | 13 | O | R-channel analog voltage output + |
| V _{OUT} R– | 12 | O | R-channel analog voltage output – |
| ZEROL | 23 | O | Zero flag for L-channel |
| ZEROR | 22 | O | Zero flag for R-channel |

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

FUNCTIONAL BLOCK DIAGRAM



TYPICAL PERFORMANCE CURVES

DIGITAL FILTER

Digital Filter Response

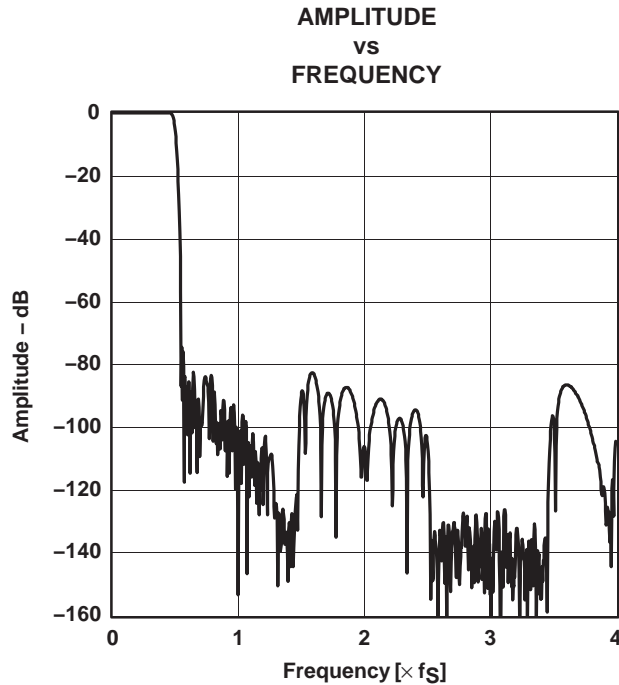


Figure 1. Frequency Response, Sharp Rolloff

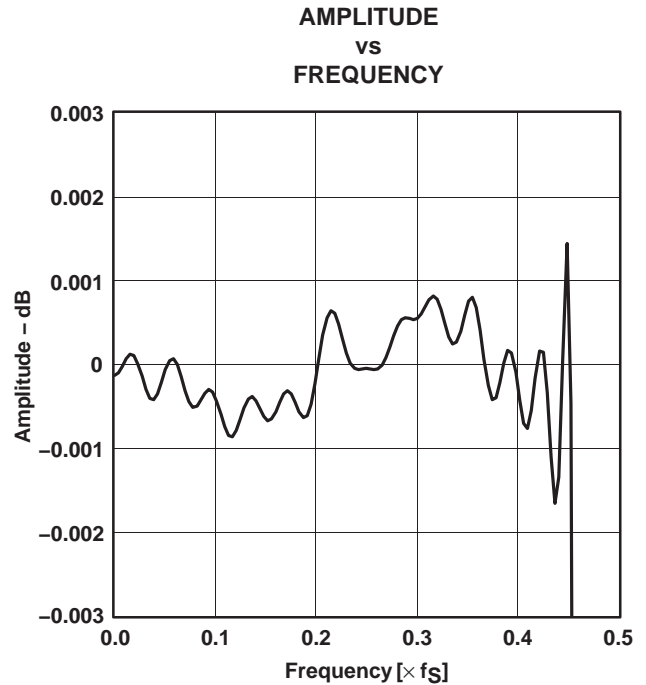


Figure 2. Pass-Band Ripple, Sharp Rolloff

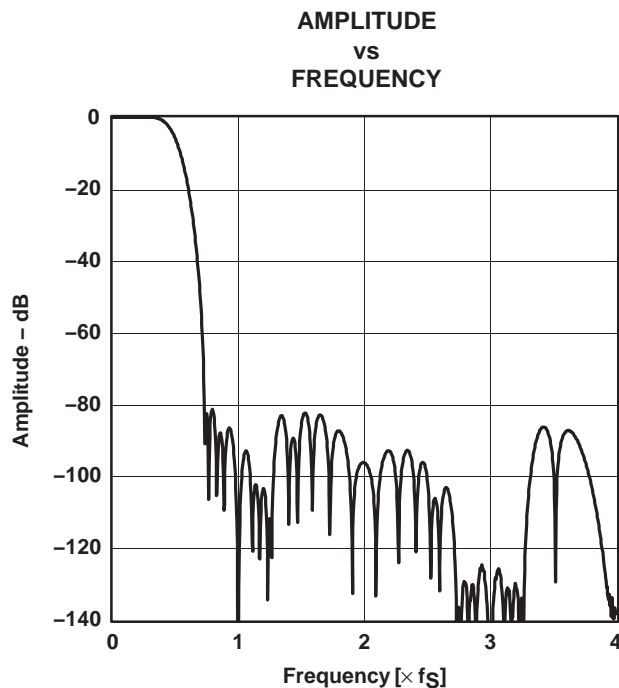


Figure 3. Frequency Response, Slow Rolloff

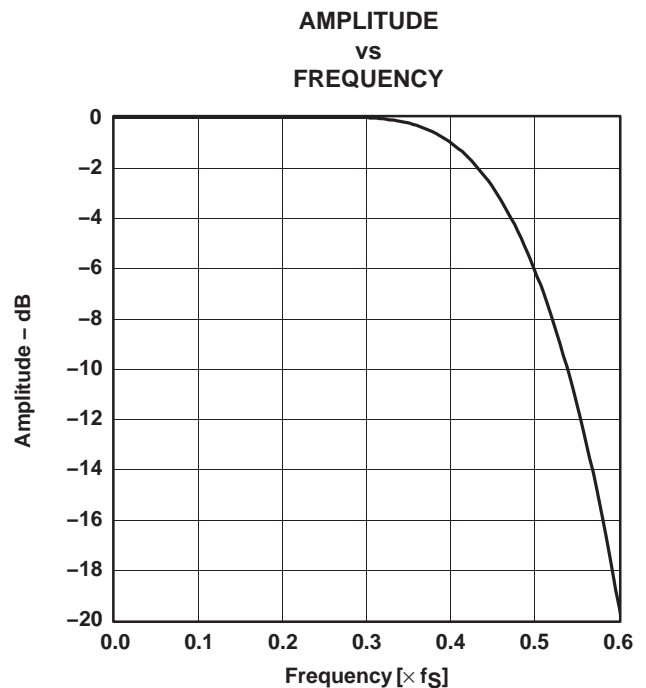


Figure 4. Transition Characteristics, Slow Rolloff

De-Emphasis Filter

DE-EMPHASIS LEVEL
VS
FREQUENCY

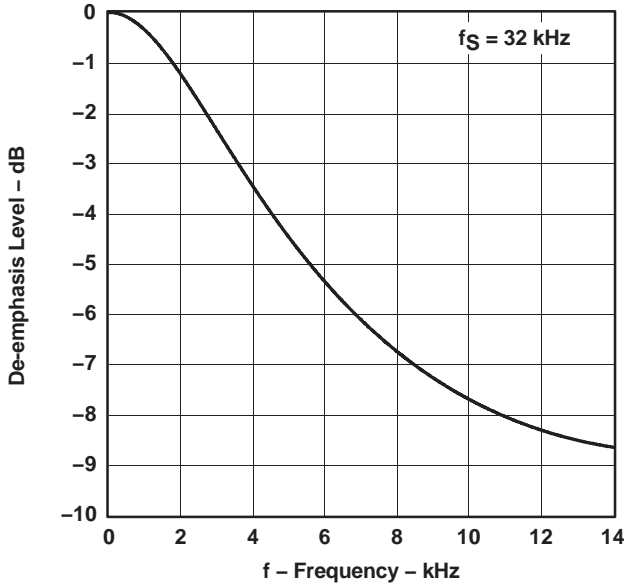


Figure 5

DE-EMPHASIS ERROR
VS
FREQUENCY

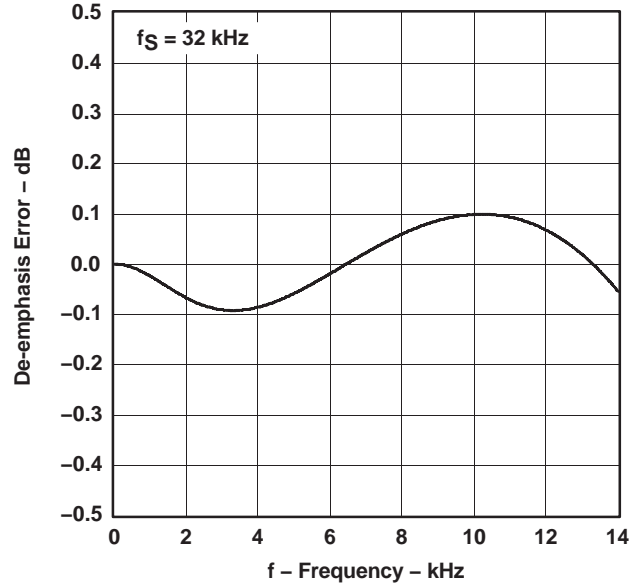


Figure 6

DE-EMPHASIS LEVEL
VS
FREQUENCY

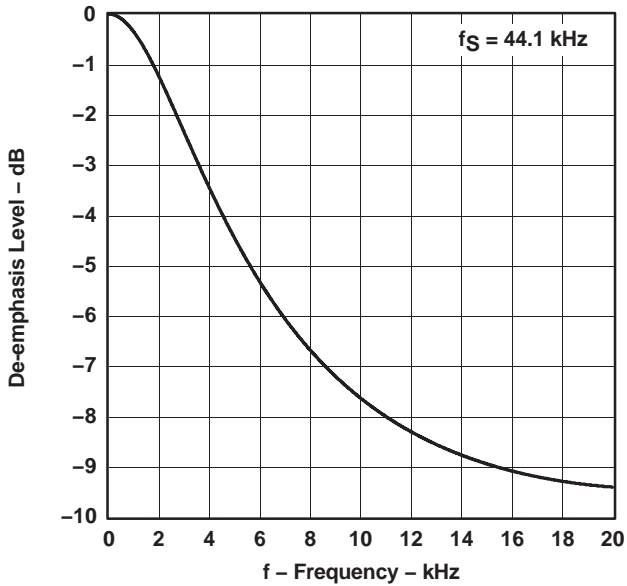


Figure 7

DE-EMPHASIS ERROR
VS
FREQUENCY

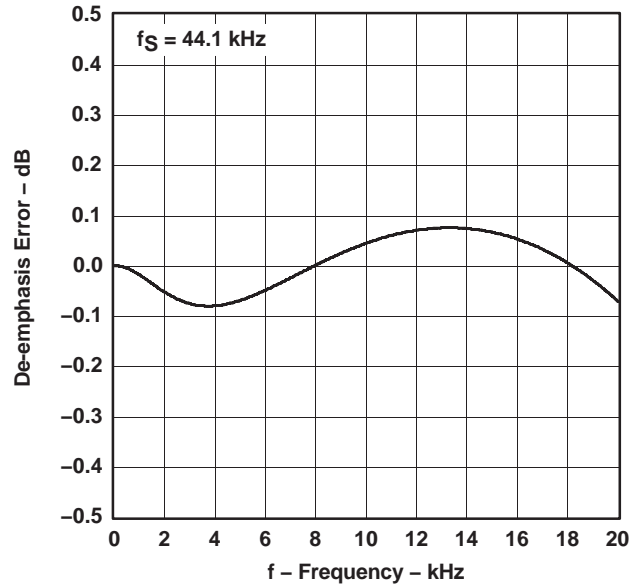
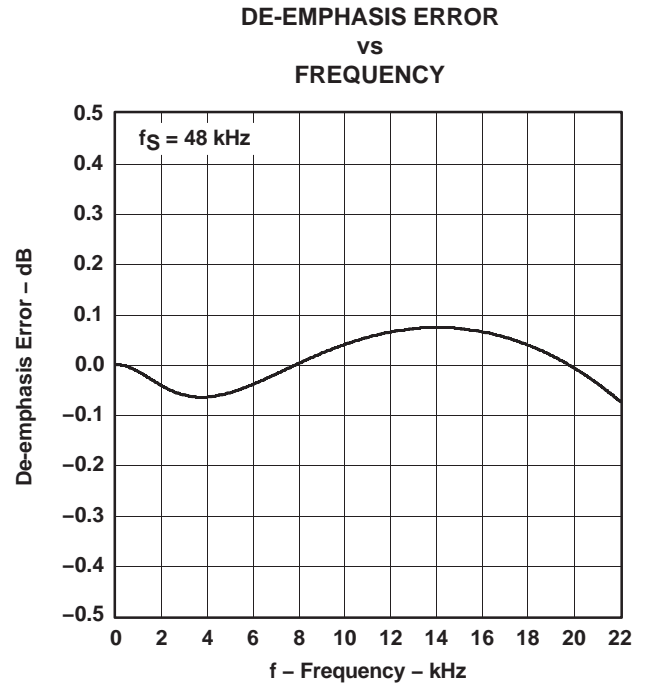
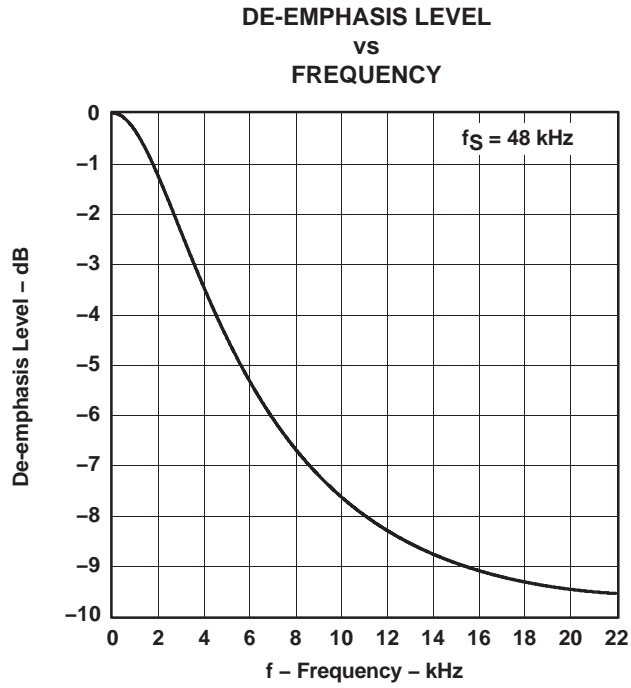


Figure 8

De-Emphasis Filter (Continued)



ANALOG DYNAMIC PERFORMANCE

Supply Voltage Characteristics

TOTAL HARMONIC DISTORTION + NOISE
vs
SUPPLY VOLTAGE

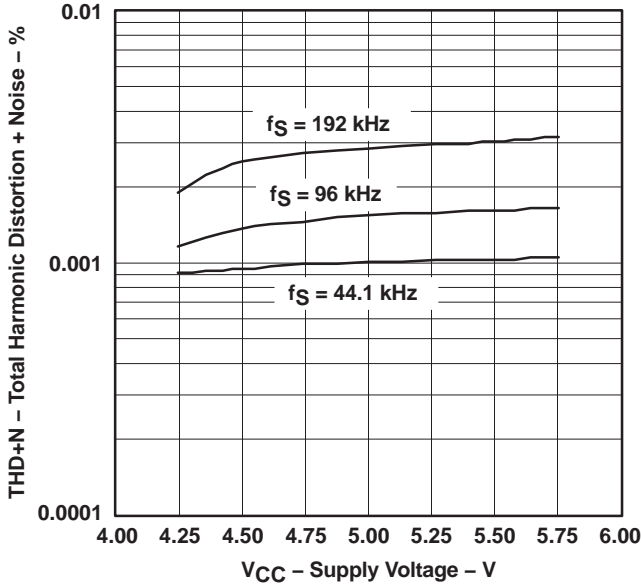


Figure 11

DYNAMIC RANGE
vs
SUPPLY VOLTAGE

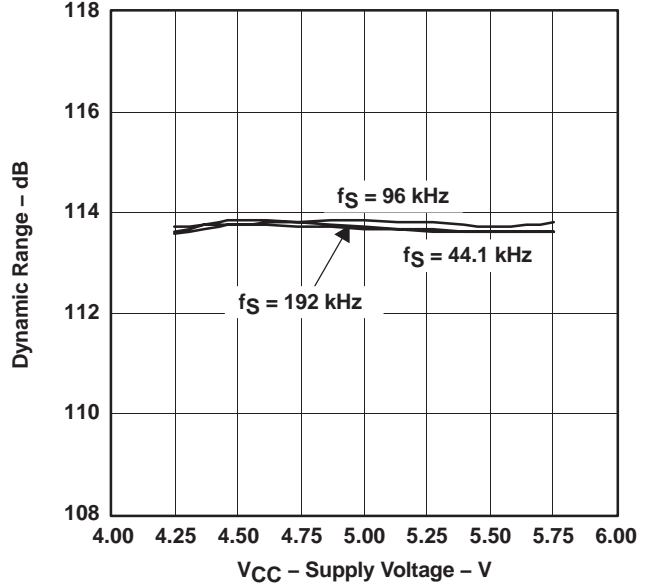


Figure 12

SIGNAL-to-NOISE RATIO
vs
SUPPLY VOLTAGE

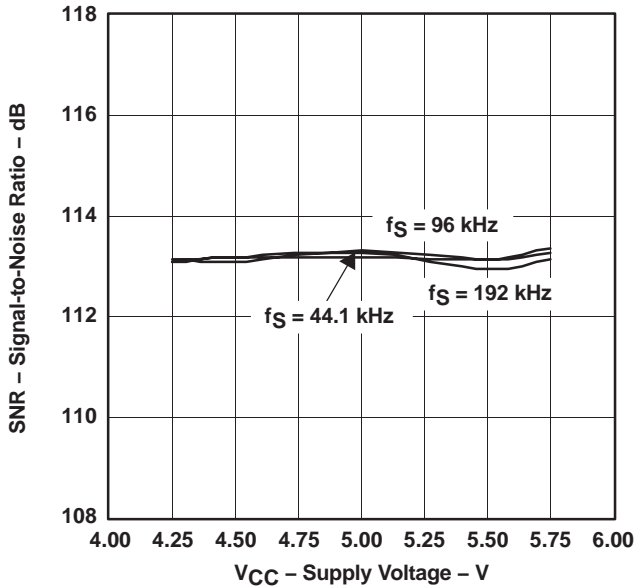


Figure 13

CHANNEL SEPARATION
vs
SUPPLY VOLTAGE

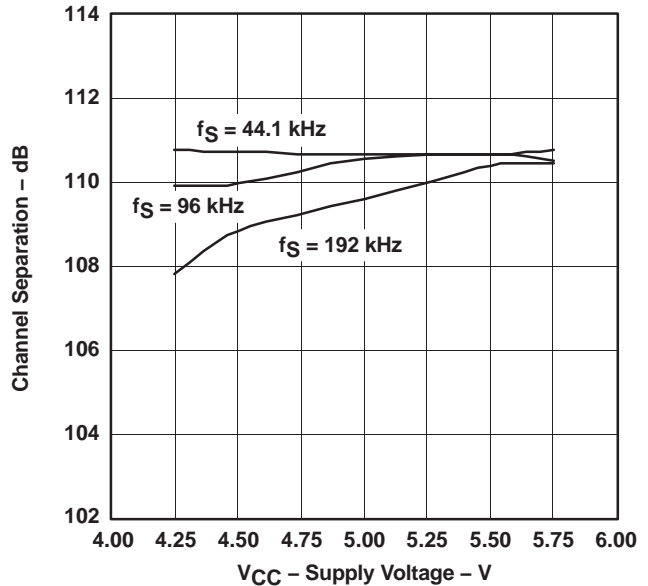


Figure 14

NOTE: PCM mode, T_A = 25°C, V_{DD} = 3.3 V.

Temperature Characteristics

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

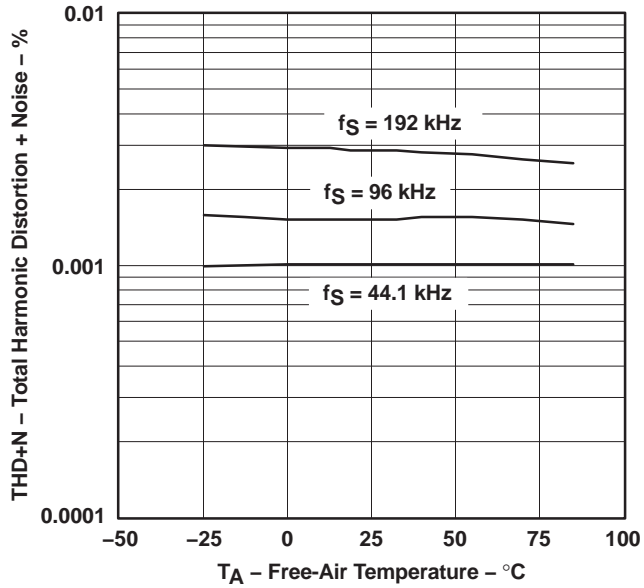


Figure 15

**DYNAMIC RANGE
VS
FREE-AIR TEMPERATURE**

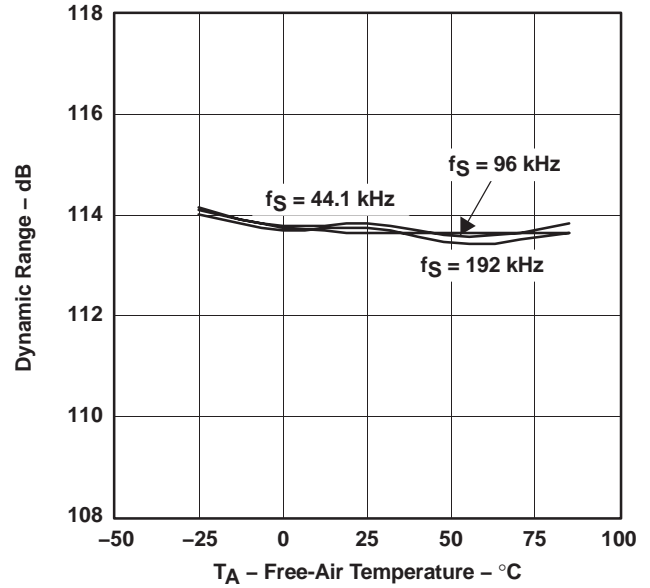


Figure 16

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

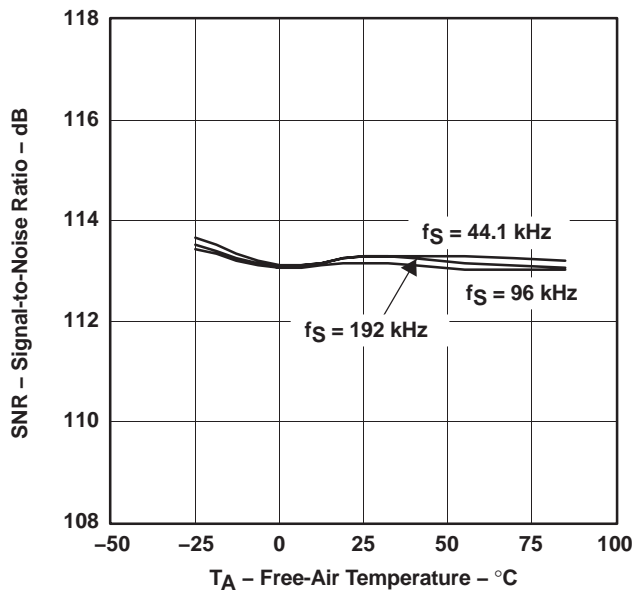


Figure 17

**CHANNEL SEPARATION
VS
FREE-AIR TEMPERATURE**

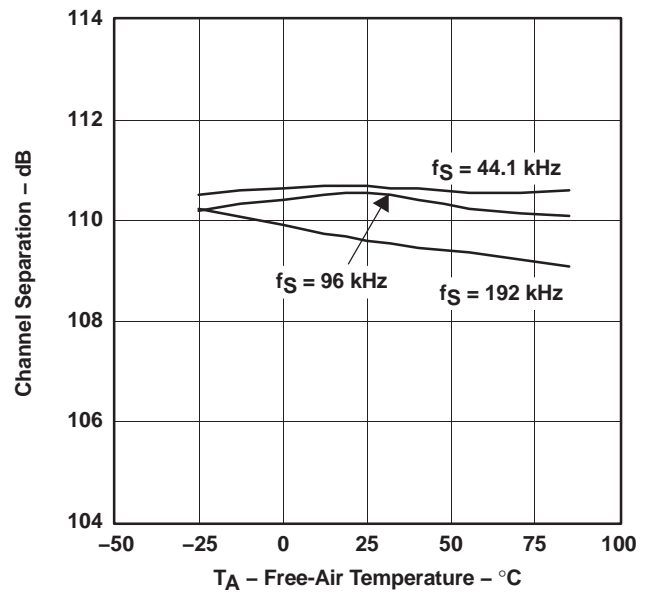


Figure 18

NOTE: PCM mode, $V_{DD} = 3.3$ V, $V_{CC} = 5$ V.

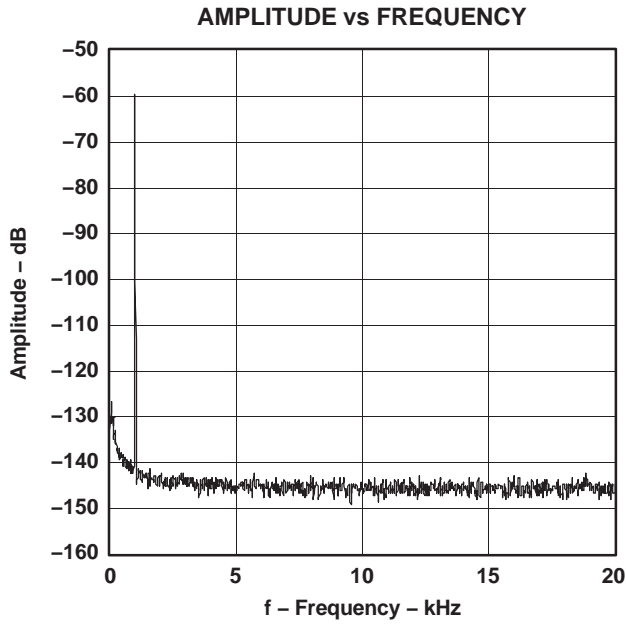


Figure 19. -60-dB Output Spectrum, BW = 20 kHz

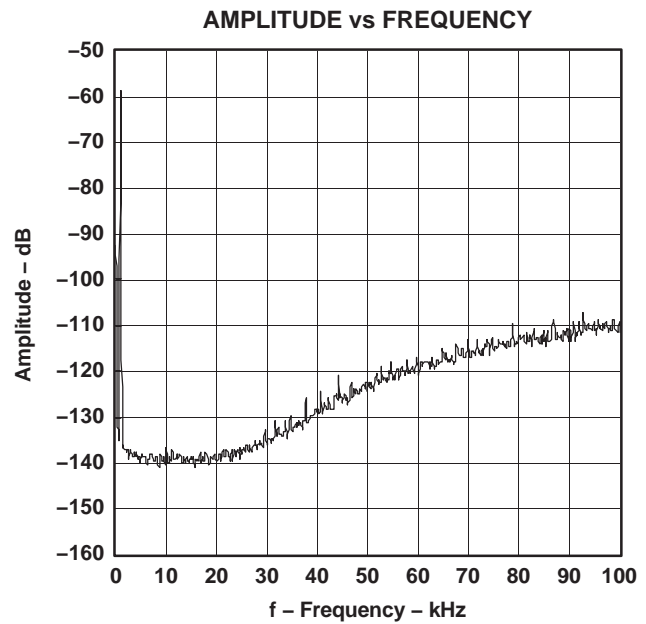


Figure 20. -60-dB Output Spectrum, BW = 100 kHz

NOTE: PCM mode, $f_S = 44.1$ kHz, 32768 points, 8 average, $T_A = 25^\circ\text{C}$, $V_{DD} = 3.3$ V, $V_{CC} = 5$ V.

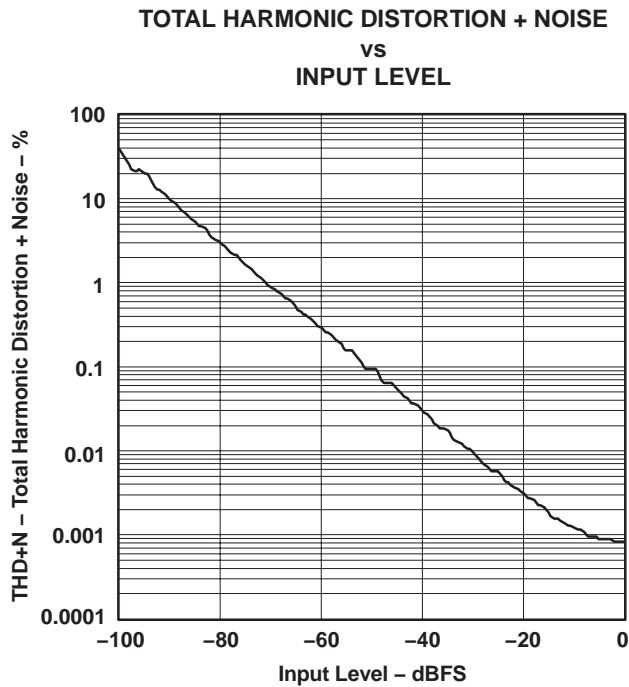


Figure 21. THD+N vs Input Level, PCM Mode

NOTE: PCM mode, $f_S = 44.1$ kHz, $T_A = 25^\circ\text{C}$, $V_{DD} = 3.3$ V, $V_{CC} = 5$ V.

SYSTEM CLOCK AND RESET FUNCTIONS

System Clock Input

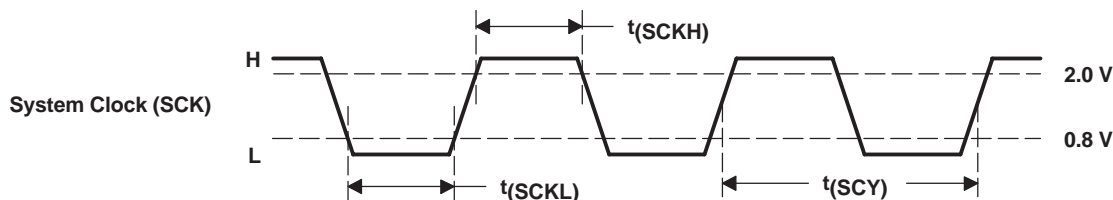
The PCM1793 requires a system clock for operating the digital interpolation filters and advanced segment DAC modulators. The system clock is applied at the SCK input (pin 5). The PCM1793 has a system clock detection circuit that automatically senses which frequency the system clock is operating. Table 1 shows examples of system clock frequencies for common audio sampling rates.

Figure 22 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 PCM1793 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 | 5 | | ns |
| $t(SCKL)$ | System clock pulse duration, LOW | 5 | | ns |

Figure 22. System Clock Input Timing

Power-On and External Reset Functions

The PCM1793 includes a power-on reset function. Figure 23 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 PCM1793 also includes an external reset capability using the \overline{RST} input (pin 6). This allows an external controller or master reset circuit to force the PCM1793 to initialize to its default reset state.

Figure 24 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 PCM1793 power up and system clock activation.

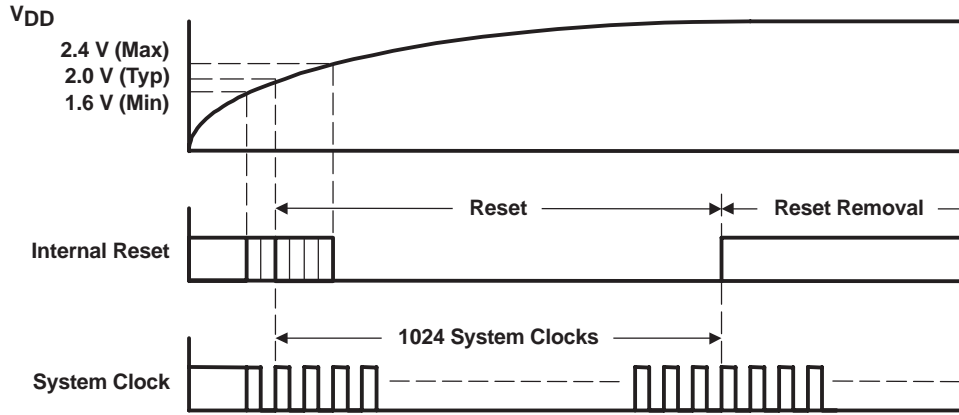
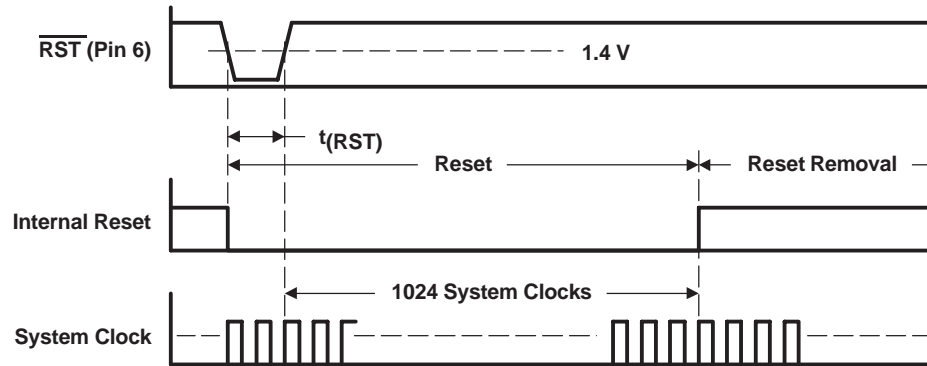


Figure 23. Power-On Reset Timing



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

Figure 24. External Reset Timing

AUDIO DATA INTERFACE

Audio Serial Interface

The audio interface port is a 3-wire serial port. It includes LRCK (pin 1), BCK (pin 2), and DATA (pin 3). 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 PCM1793 on the rising edge of BCK. LRCK is the serial audio left/right word clock.

The PCM1793 requires the synchronization of LRCK and the system clock, but does not need a specific phase relation between LRCK and the system clock.

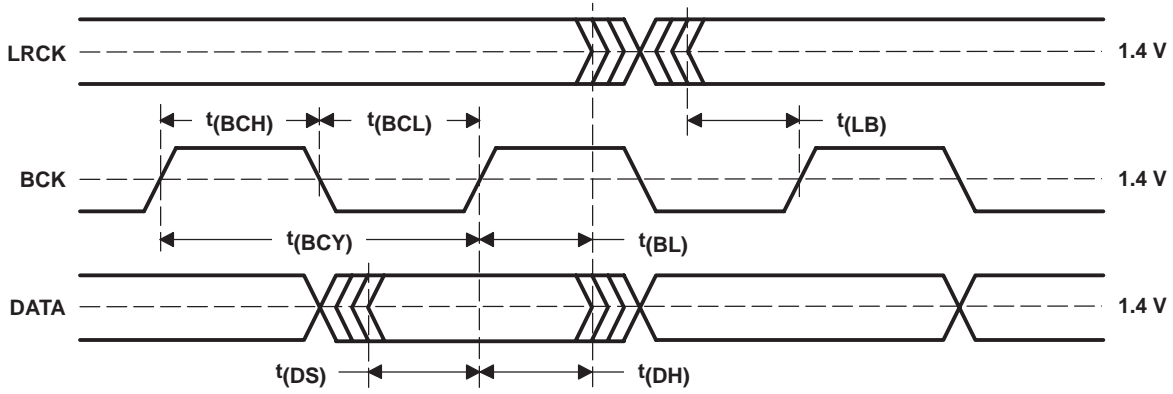
If the relationship between LRCK and the system clock changes more than ± 6 BCK, internal operation is initialized within $1/f_S$ and the analog outputs are forced to the bipolar zero level until resynchronization between LRCK and the system clock is completed.

PCM Audio Data Formats and Timing

The PCM1793 supports industry-standard audio data formats, including standard right-justified, I²S, and left-justified. The data formats are shown in Figure 26. Data formats are selected using the format bits, FMT2 (pin 28), FMT1 (pin 27), and FMT0 (pin 26) as shown in Table 2. All formats require binary 2s complement, MSB-first audio data. Figure 25 shows a detailed timing diagram for the serial audio interface.

Table 2. Audio Data Format Selection

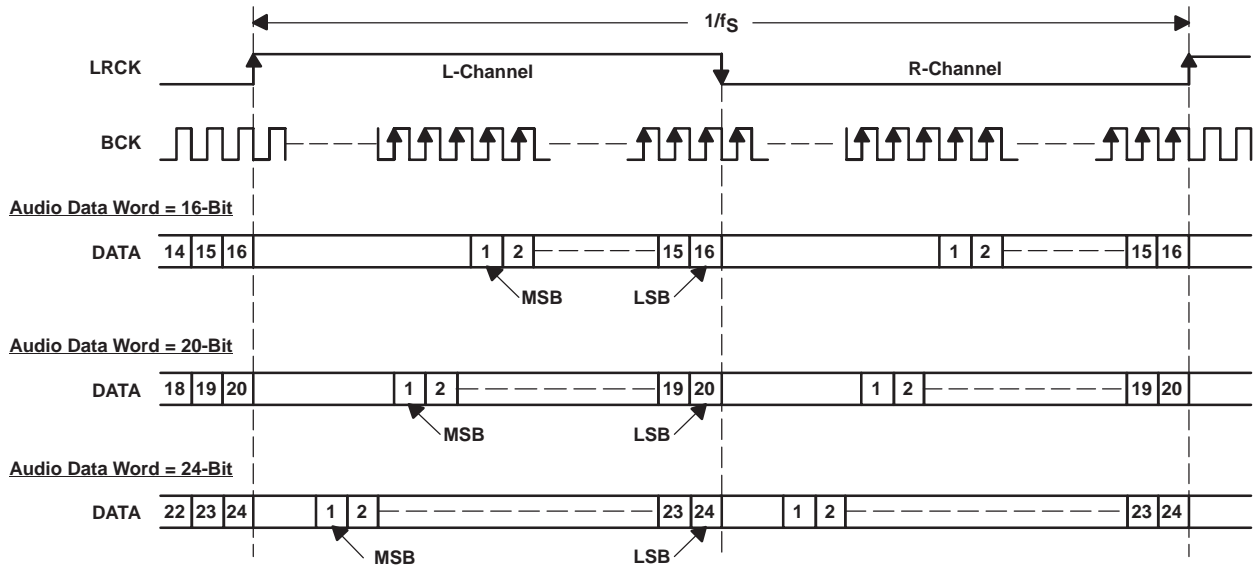
| FMT2 PIN 28 | FMT1 PIN 27 | FMT0 PIN 26 | FORMAT |
|----------------|----------------|----------------|---|
| LOW | LOW | LOW | 16-bit standard format, right-justified |
| LOW | LOW | HIGH | 20-bit standard format, right-justified |
| LOW | HIGH | LOW | 24-bit standard format, right-justified |
| LOW | HIGH | HIGH | 24-bit MSB-first, left-justified format |
| HIGH | LOW | LOW | 16-bit I ² S format |
| HIGH | LOW | HIGH | 24-bit I ² S format |
| HIGH | HIGH | LOW | Reserved |
| HIGH | HIGH | HIGH | Reserved |



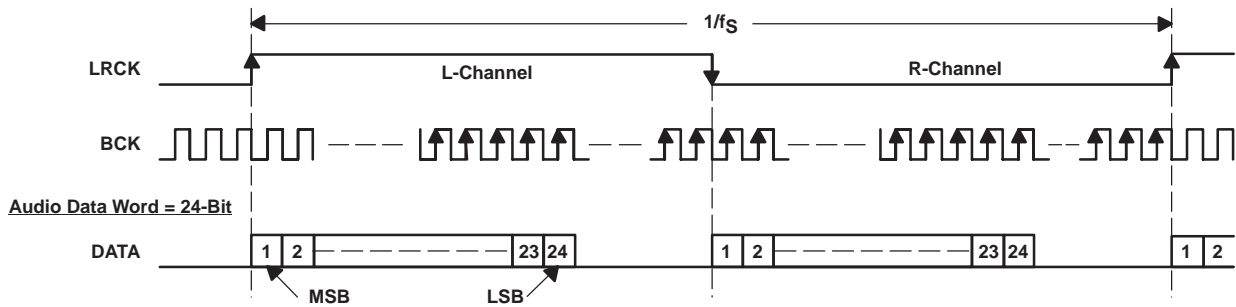
| PARAMETERS | | MIN | MAX | UNITS |
|------------|------------------------------|--------------------|-----|-------|
| t(BCY) | BCK pulse cycle time | 70 | | ns |
| t(BCL) | BCK pulse duration, LOW | 30 | | ns |
| t(BCH) | BCK pulse duration, HIGH | 30 | | ns |
| t(BL) | BCK rising edge to LRCK edge | 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% ± 2 bit clocks | | |

Figure 25. 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

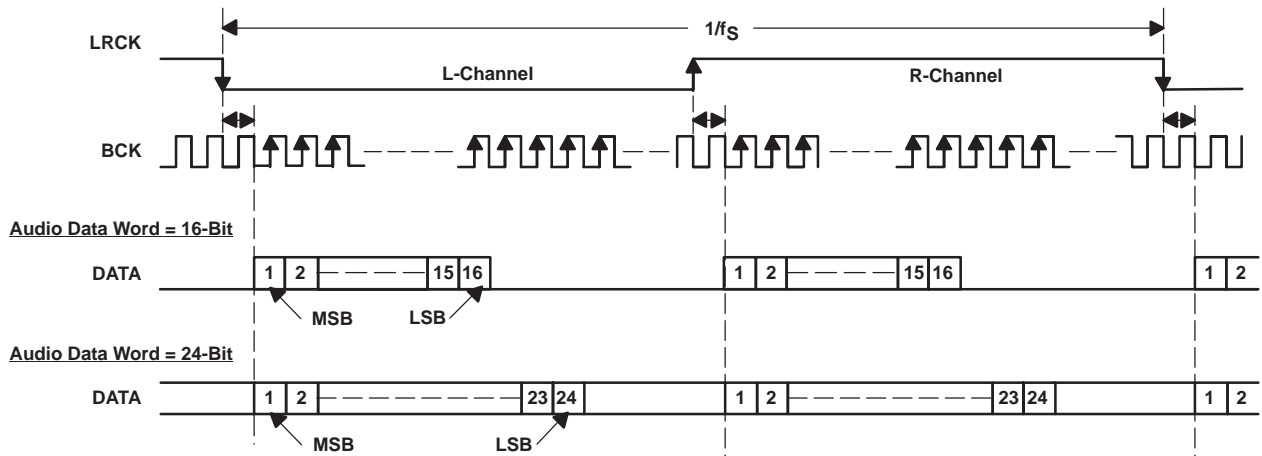


Figure 26. Audio Data Input Formats

FUNCTION DESCRIPTIONS

Zero Detect

When the PCM1793 detects that the audio input data in the L-channel or R-channel is continuously zero for $1024 f_S$, the PCM1793 sets ZEROL (pin 23) or ZEROR (pin 22) to HIGH.

Soft Mute

The PCM1793 supports mute operation. When MUTE (pin 4) 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 PCM1793 has de-emphasis filters for sampling frequencies of 32 kHz, 44.1 kHz, and 48 kHz. DEMP1 (pin 25) and DEMP0 (pin 24) select the sampling frequency for which de-emphasis filtering is performed, as shown in Table 3.

Table 3. De-Emphasis Control

| DEMP1 PIN 25 | DEMP0 PIN 24 | DE-EMPHASIS FUNCTION |
|-----------------|-----------------|----------------------|
| LOW | LOW | Disabled |
| LOW | HIGH | 48 kHz |
| HIGH | LOW | 44.1 kHz |
| HIGH | HIGH | 32 kHz |

TYPICAL CONNECTION DIAGRAM

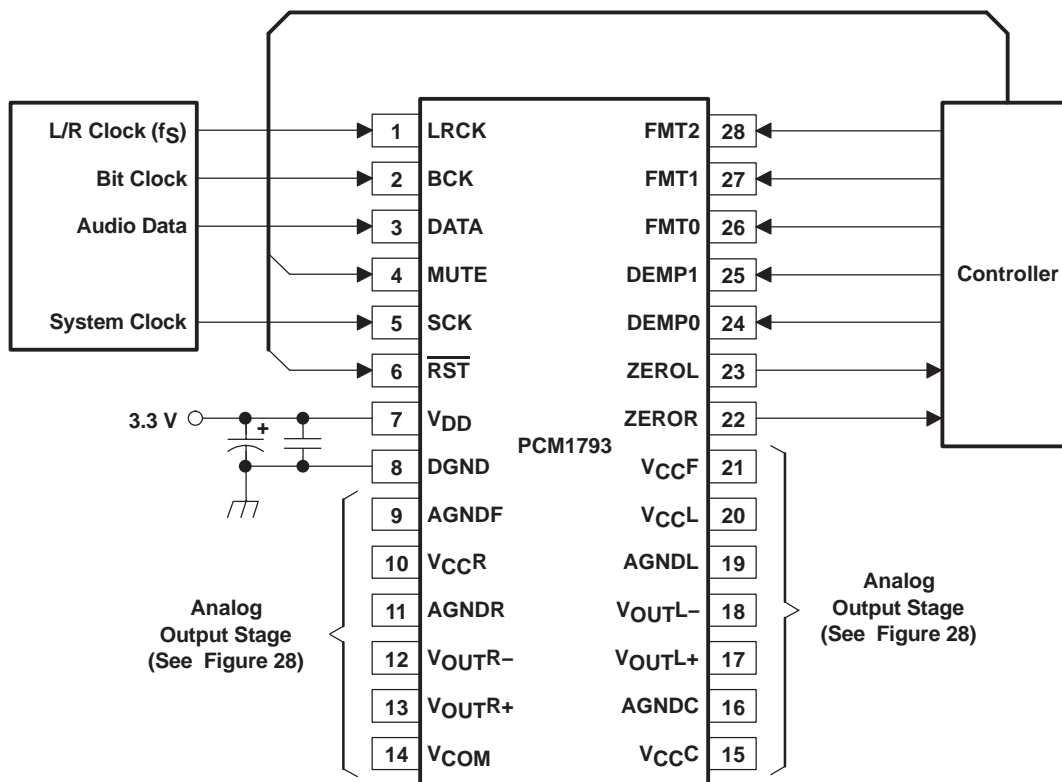
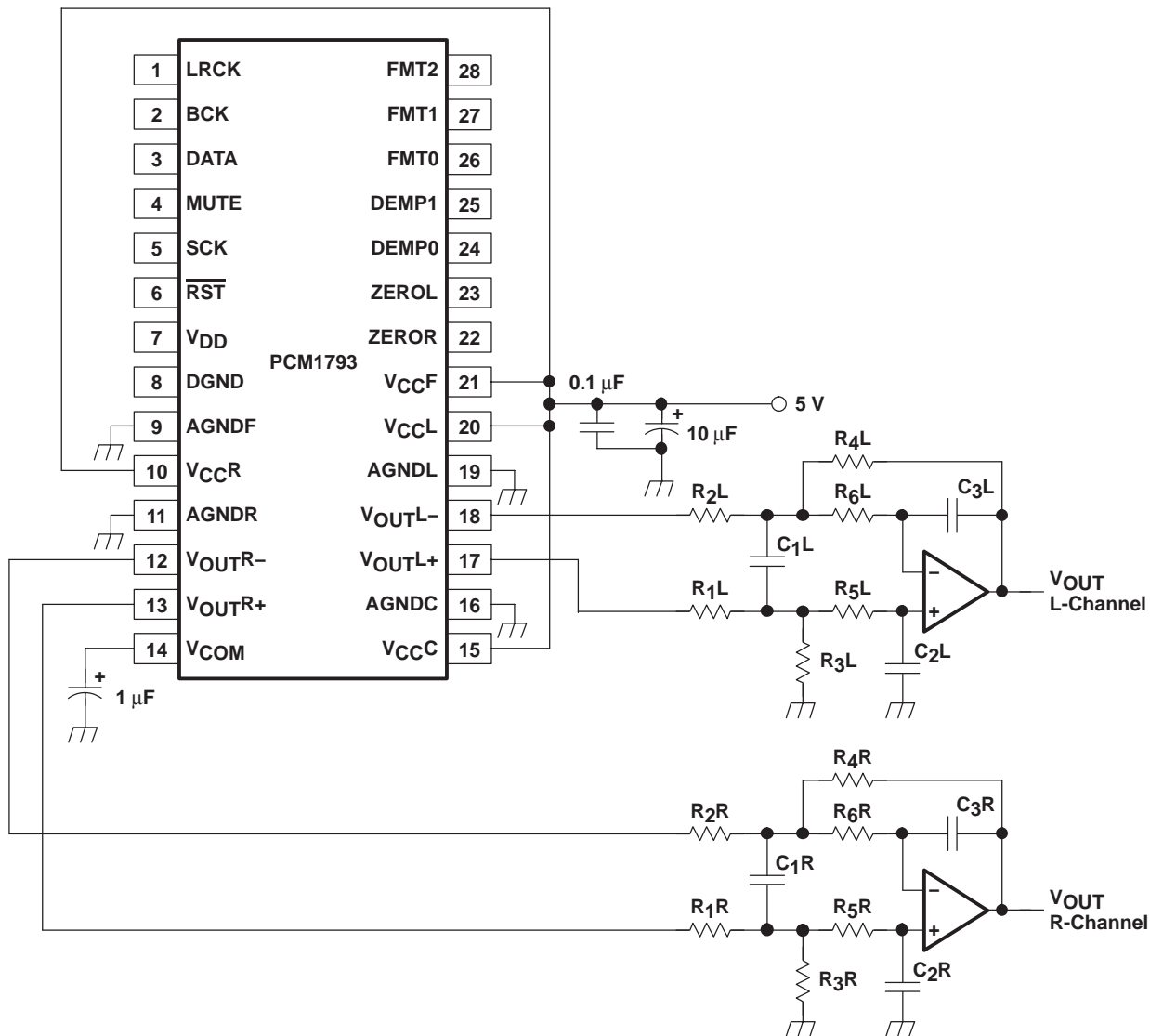


Figure 27. Typical Application Circuit

APPLICATION INFORMATION

ANALOG OUTPUTS



NOTE: Example R and C values for $f_C = 77$ kHz – R_1, R_2 : 1.8 k Ω , R_3, R_4 : 3.3 k Ω , R_5, R_6 : 680 Ω , C_1 : 1800 pF, C_2, C_3 : 560 pF.

Figure 28. Typical Application for Analog Output Stage

Analog Output Level and LPF

The signal level of the DAC differential-voltage output $\{(V_{OUTL+}) - (V_{OUTL-}), (V_{OUTR+}) - (V_{OUTR-})\}$ is 3.2 V_{p-p} at 0 dB (full scale). The voltage output of the LPF is given by following equation:

$$V_{OUT} = 3.2 \text{ V}_{p-p} \times (R_f / R_i)$$

Here, R_f is the feedback resistor in the LPF, and $R_3 = R_4$ in a typical application circuit. R_i is the input resistor in the LPF, and $R_1 = R_2$ in a typical application circuit.

Op Amp for LPF

An OPA2134 or 5532 type op amp is recommended for the LPF circuit to obtain the specified audio performance. Dynamic performance such as gain bandwidth, settling time, and slew rate of the op amp largely determines the audio dynamic performance of the LPF section. The input noise specification of the op amp should be considered to obtain a 113-dB S/N ratio.

Analog Gain of Balanced Amplifier

The DAC voltage outputs are followed by balanced amplifier stages, which sum the differential signals for each channel, creating a single-ended voltage output. In addition, the balanced amplifiers provide a third-order low-pass filter function, which band limits the audio output signal. The cutoff frequency and gain are determined by external R and C component values. In this case, the cutoff frequency is 77 kHz with a gain of 1.83. The output voltage for each channel is 5.9 Vp-p, or 2.1 V rms.

THEORY OF OPERATION

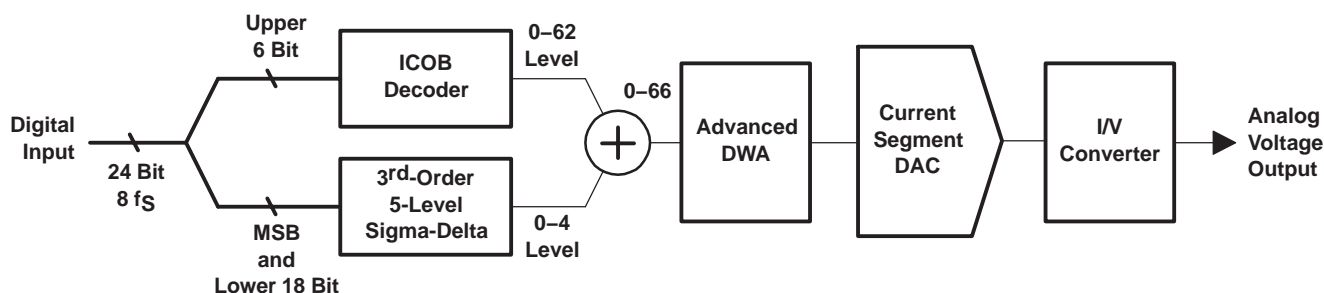


Figure 29. Advanced Segment DAC With I/V Converter

The PCM1793 uses TI's advanced segment DAC architecture to achieve excellent dynamic performance and improved tolerance to clock jitter. The PCM1793 provides balanced voltage 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 fs 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 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.

CONSIDERATIONS FOR APPLICATION CIRCUITS

PCB Layout Guidelines

A typical PCB floor plan for the PCM1793 is shown in Figure 30. A ground plane is recommended, with the analog and digital sections being isolated from one another using a split or cut in the circuit board. The PCM1793 must be oriented with the digital I/O pins facing the ground plane split/cut to allow for short, direct connections to the digital audio interface and control signals originating from the digital section of the board. Separate power supplies are recommended for the digital and analog sections of the board. This prevents the switching noise present on the digital supply from contaminating the analog power supply and degrading the dynamic performance of the D/A converters. In cases where a common 5-V supply would be used for the analog and digital sections, an inductance (RF choke, ferrite bead) must be placed between the analog and digital 5-V supply connections to avoid coupling of the digital switching noise into the analog circuitry. Figure 31 shows the recommended approach for single-supply applications.

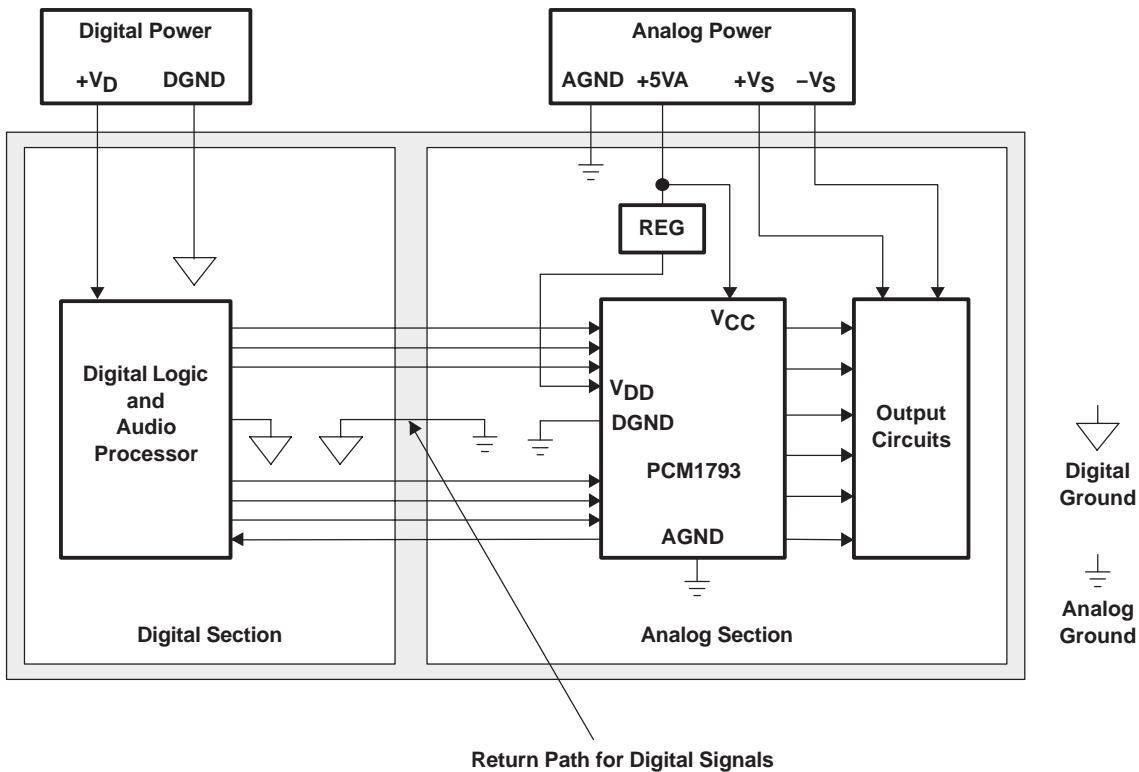


Figure 30. Recommended PCB Layout

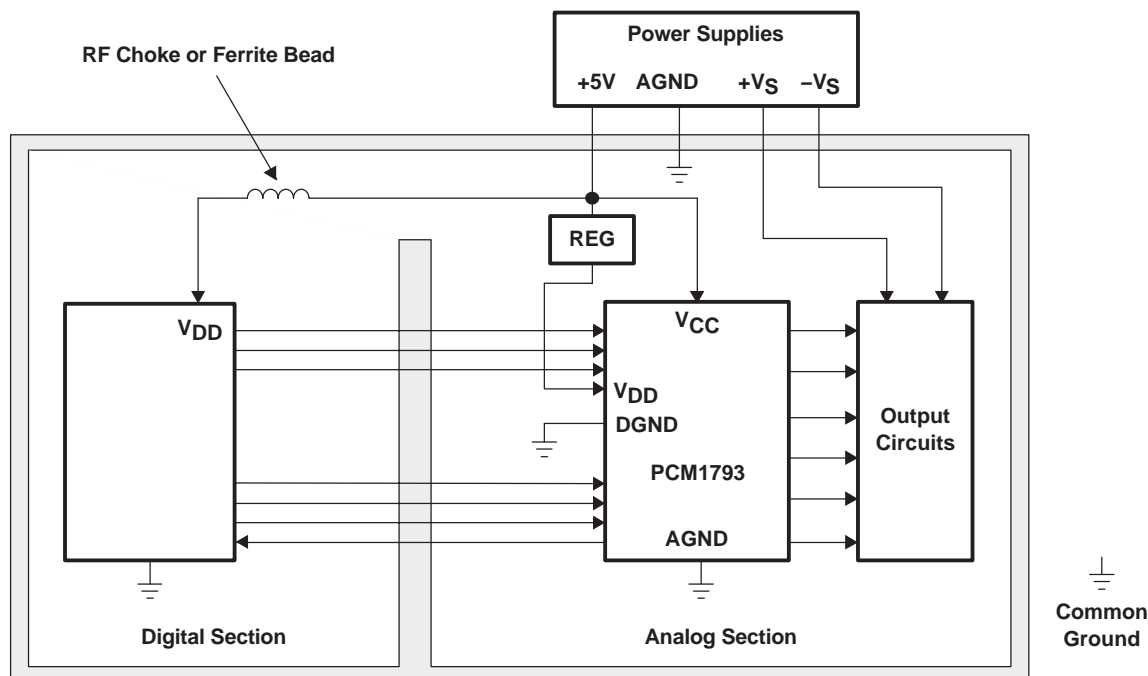


Figure 31. Single-Supply PCB Layout

Bypass and Decoupling Capacitor Requirements

Various-sized decoupling capacitors can be used, with no special tolerances being required. All capacitors must be located as close as possible to the appropriate pins of the PCM1793 to reduce noise pickup from surrounding circuitry. Aluminum electrolytic capacitors that are designed for hi-fi audio applications are recommended for larger values, while metal film or monolithic ceramic capacitors are used for smaller values.

Post-LPF Design

By proper choice of the op amp and resistors used in the post-LPF circuit, excellent performance of the PCM1793 should be achieved. To obtain 0.001% THD+N, 113 dB signal-to-noise-ratio audio performance, the THD+N and input noise performance of the op amp must be considered. This is because the input noise of the op amp contributes directly to the output noise level of the application. The V_{OUT} pins of the PCM1793 and the input resistor of the post-LPF circuit must be connected as closely as possible.

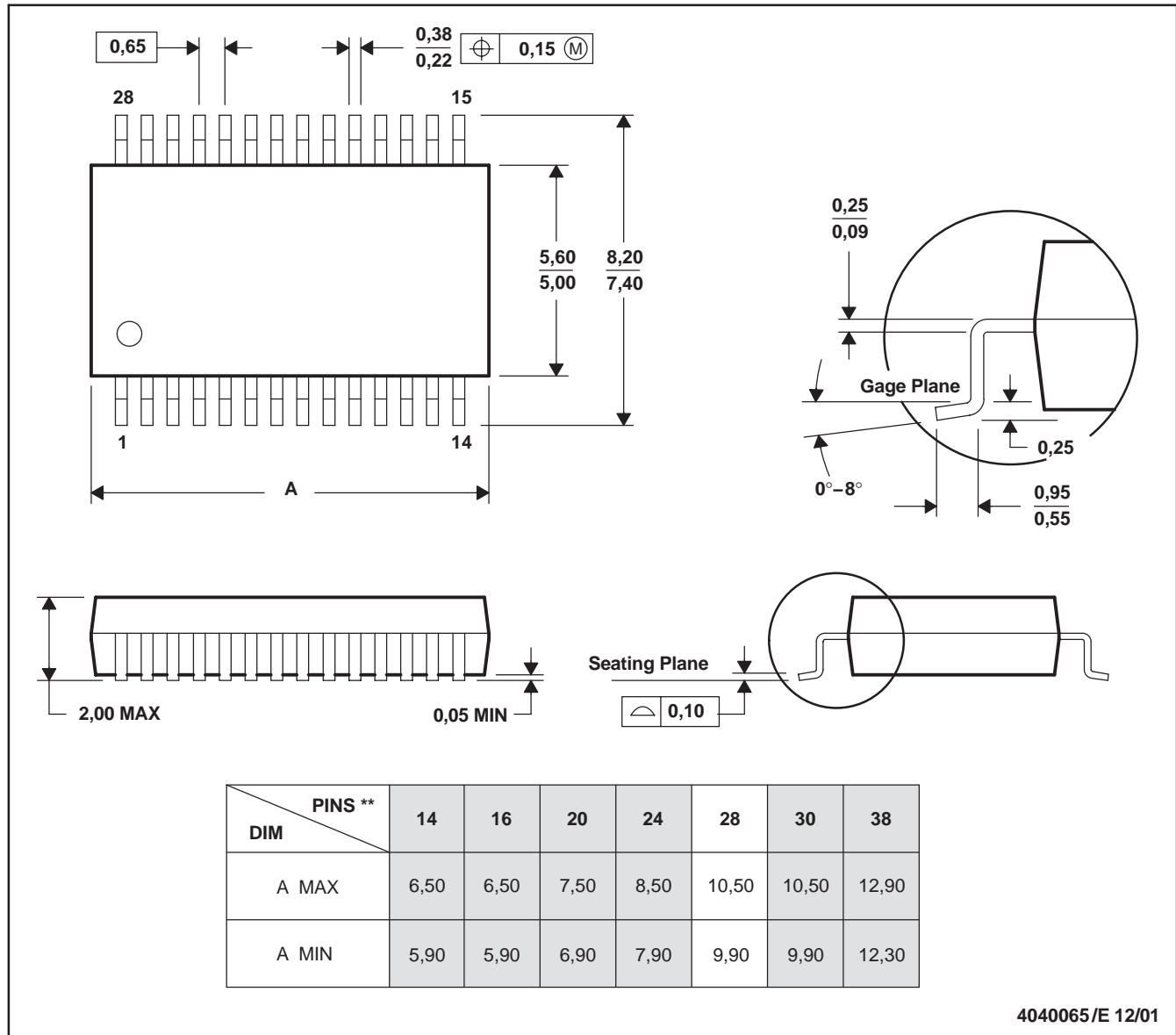
Out-of-band noise level and attenuated sampling spectrum level are much lower than for typical delta-sigma type DACs due to the combination of a high-performance digital filter and advanced segment DAC architecture. The use of a second-order or third-order post-LPF is recommended for the post-LPF of the PCM1793. The cutoff frequency of the post-LPF depends on the application. For example, there are many sampling-rate operations such as $f_S = 44.1$ kHz on CDDA, $f_S = 96$ kHz on DVD-M, $f_S = 192$ kHz on DVD-A, $f_S = 64 f_S$ on DSD (SACD).

MECHANICAL DATA

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

PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|----------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| PCM1793DB | Active | Production | SSOP (DB) 28 | 47 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | PCM1793 |
| PCM1793DB.B | Active | Production | SSOP (DB) 28 | 47 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | PCM1793 |
| PCM1793DBG4 | Active | Production | SSOP (DB) 28 | 47 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | PCM1793 |
| PCM1793DBR | Active | Production | SSOP (DB) 28 | 2000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | PCM1793 |
| PCM1793DBR.B | Active | Production | SSOP (DB) 28 | 2000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | PCM1793 |

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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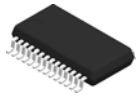
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TUBE


*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|-------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| PCM1793DB | DB | SSOP | 28 | 47 | 500 | 10.6 | 500 | 9.6 |
| PCM1793DB.B | DB | SSOP | 28 | 47 | 500 | 10.6 | 500 | 9.6 |
| PCM1793DBG4 | DB | SSOP | 28 | 47 | 500 | 10.6 | 500 | 9.6 |

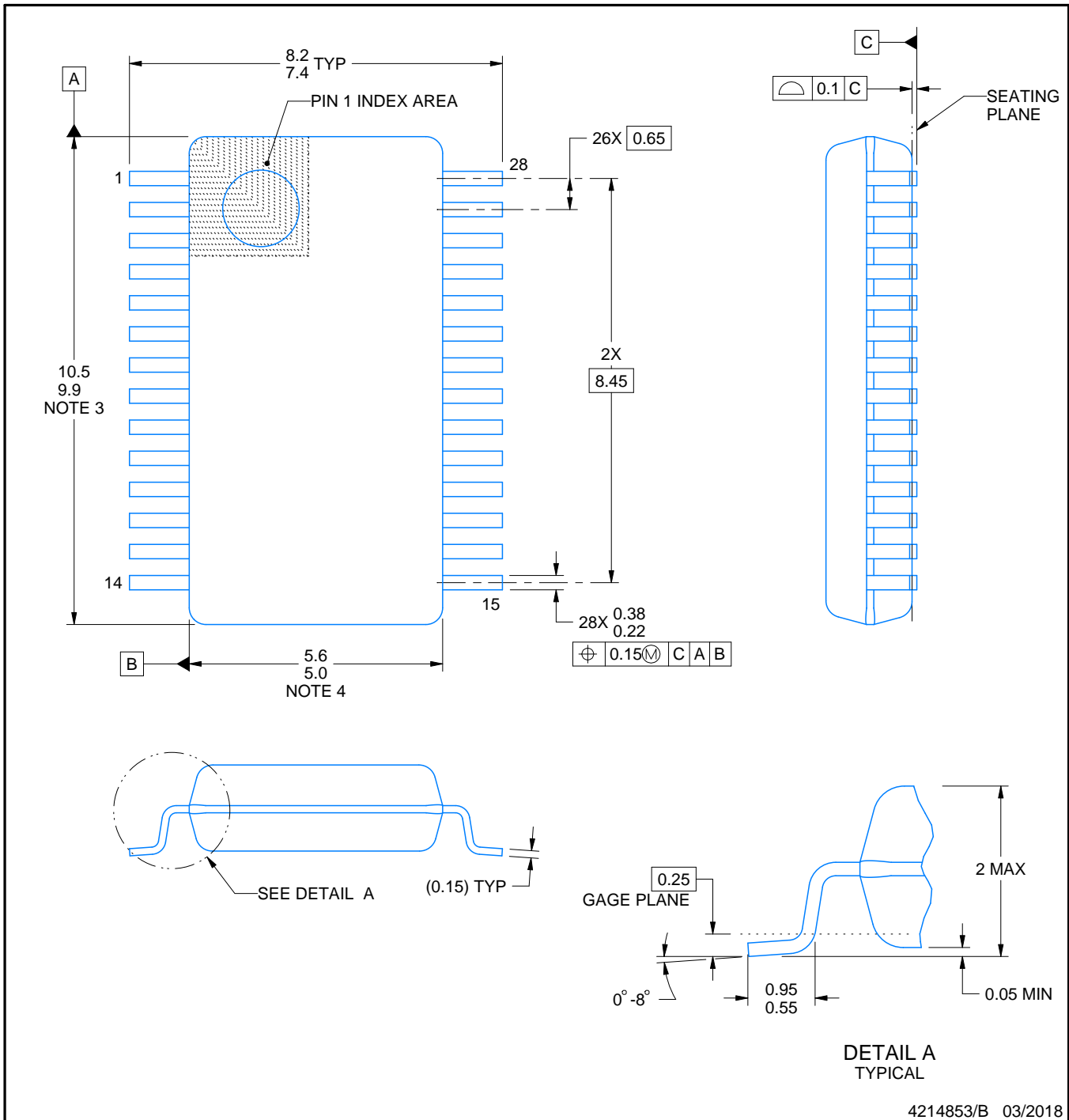
DB0028A



PACKAGE OUTLINE

SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



4214853/B 03/2018

NOTES:

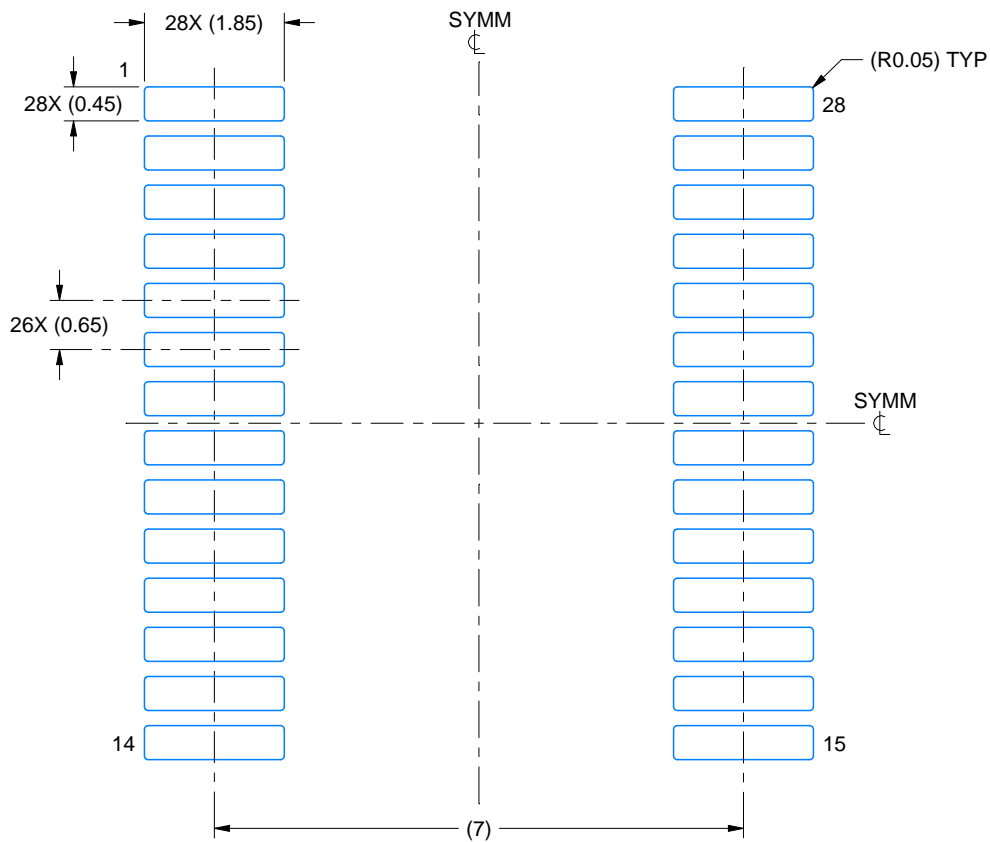
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-150.

EXAMPLE BOARD LAYOUT

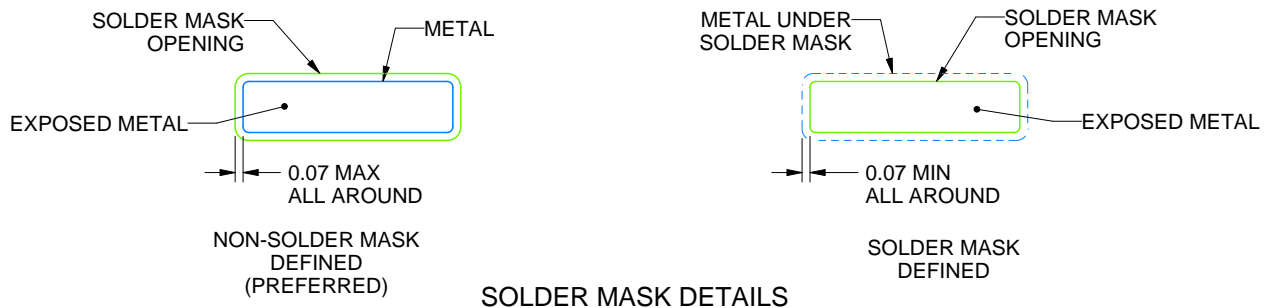
DB0028A

SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



4214853/B 03/2018

NOTES: (continued)

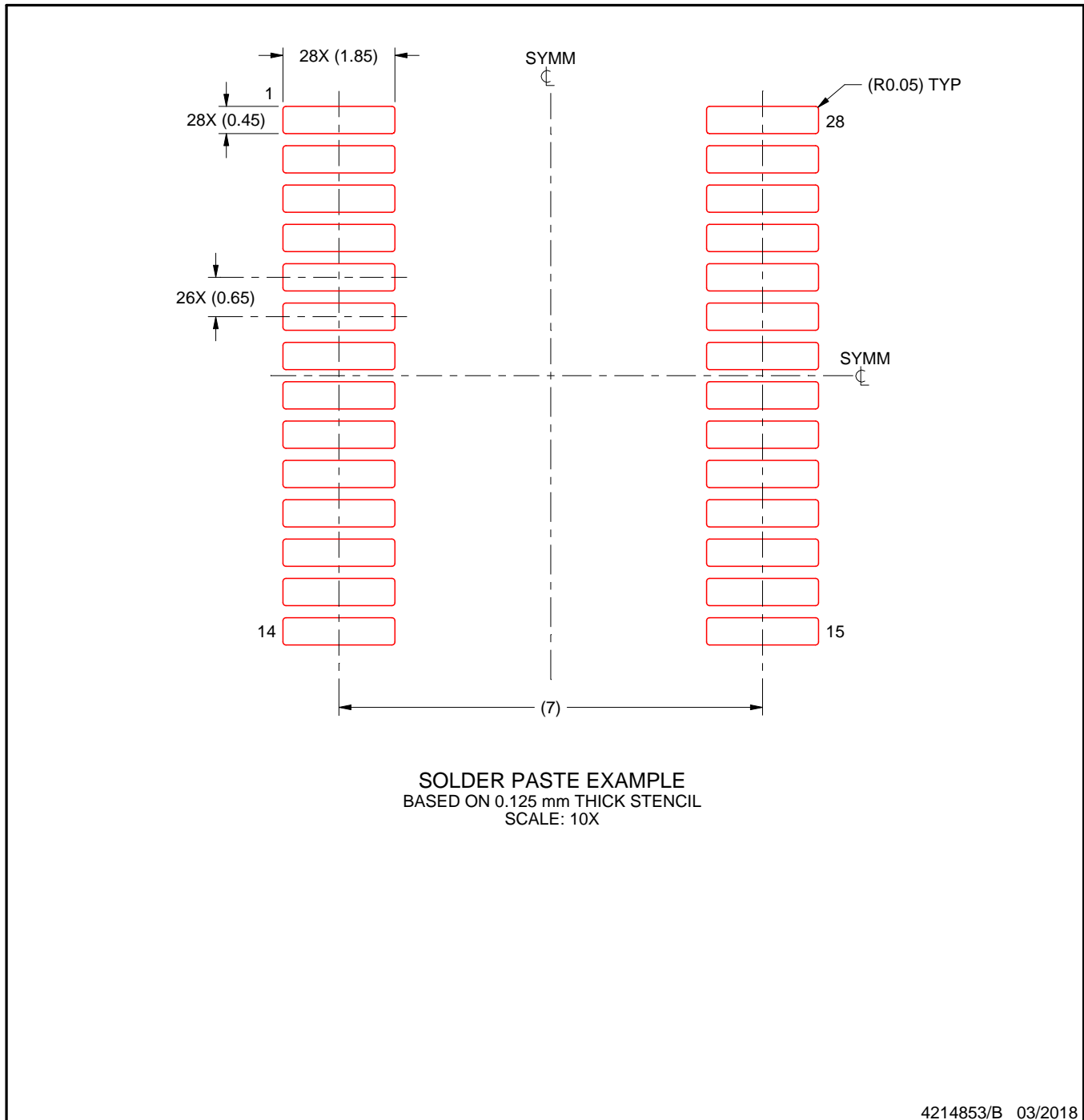
- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DB0028A

SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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