

PCM1726

## SoundPlus™ Stereo Audio DIGITAL-TO-ANALOG CONVERTER 16 Bits, 96kHz Sampling

### FEATURES

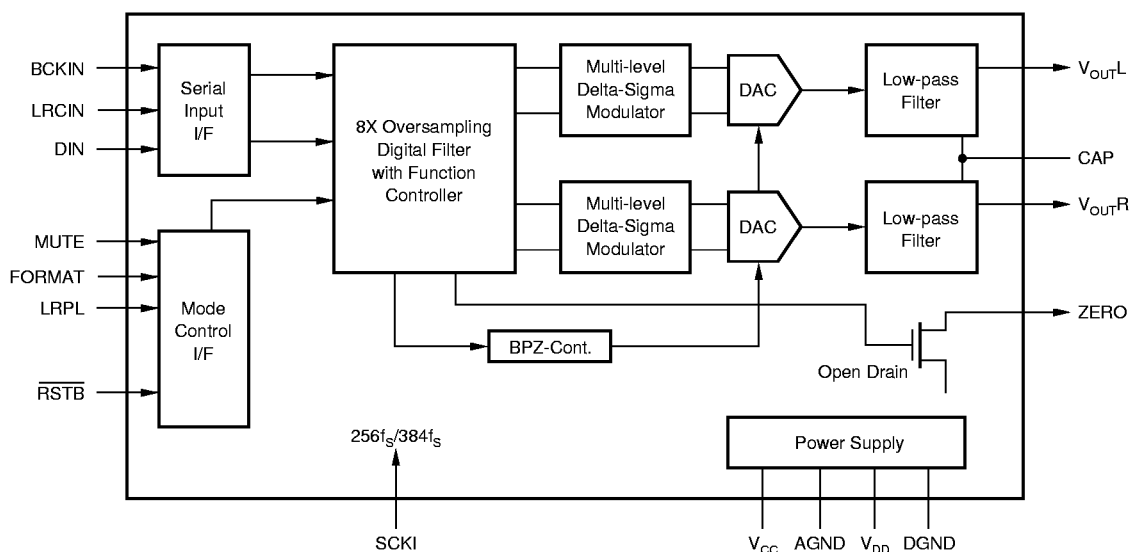
- **COMPLETE STEREO DAC:** Includes Digital Filter and Output Amp
- **DYNAMIC RANGE:** 96dB
- **MULTIPLE SAMPLING FREQUENCIES:** 16kHz to 96kHz  
8X Oversampling at All Sampling Frequencies
- **SYSTEM CLOCK:** 256f<sub>S</sub>/384f<sub>S</sub>
- **NORMAL OR I<sup>2</sup>S DATA INPUT FORMATS**
- **SOFT MUTE**

### DESCRIPTION

The PCM1726 is a complete low cost stereo audio digital-to-analog converter (DAC), operating off of a 256f<sub>S</sub> or 384f<sub>S</sub> system clock. The DAC contains a 3rd-order ΔΣ modulator, a digital interpolation filter, and an analog output amplifier. The PCM1726 accepts 16-bit input data in either normal or I<sup>2</sup>S formats.

The digital filter performs an 8X interpolation function and includes soft mute. The PCM1726 can accept standard digital audio sampling frequencies as well as one-half and double sampling frequencies.

The PCM1726 is ideal for applications which combine compressed audio and video data such as DVD, DVD-ROM, set-top boxes and MPEG sound cards.



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Internet: <http://www.burr-brown.com/> • FAXLine: (800) 548-6133 (US/Canada Only) • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

# SPECIFICATIONS

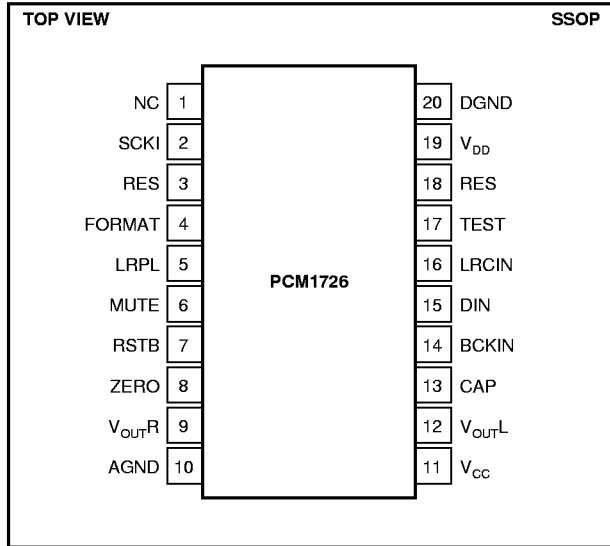
All specifications at +25°C, +V<sub>CC</sub> = +V<sub>DD</sub> = +5V, f<sub>S</sub> = 44.1kHz, and 16-bit input data, SYSCLK = 384f<sub>S</sub>, unless otherwise noted.

| PARAMETER   | CONDITIONS   | PCM1726 |                                      |       | UNITS            |
|---|--|---------|--------------------------------------|-------|------------------|
|   |  | MIN     | TYP                                  | MAX   |                  |
| <b>RESOLUTION</b>                                 |  |         |                                      | 16    | Bits             |
| <b>DATA FORMAT</b>                                |  |         |                                      |       |                  |
| Audio Data Format                                 |  |         | Standard/I <sup>2</sup> S            |       |                  |
| Data Bit Length                                   |  |         | 16                                   |       |                  |
| Sampling Frequency (f <sub>S</sub> )              |  | 16      |                                      | 96    | kHz              |
| Internal System Clock Frequency                   |  |         | 256f <sub>S</sub> /384f <sub>S</sub> |       |                  |
| <b>DIGITAL INPUT/OUTPUT LOGIC LEVEL</b>           |  |         | TTL                                  |       |                  |
| <b>DYNAMIC PERFORMANCE<sup>(1)</sup></b>          |  |         |                                      |       |                  |
| THD+N at f <sub>S</sub> (0dB)                     | f <sub>S</sub> = 44.1kHz   |         | -90                                  | -80   | dB               |
|   | f <sub>S</sub> = 96kHz   |         | -88                                  |       | dB               |
| THD+N at -60dB                                    | f <sub>S</sub> = 44.1kHz   |         | -34                                  |       | dB               |
|   | f <sub>S</sub> = 96kHz   |         | -31                                  |       | dB               |
| Dynamic Range                                     | f <sub>S</sub> = 44.1kHz   | 90      | 96                                   |       | dB               |
|   | f <sub>S</sub> = 96kHz   |         | 93                                   |       | dB               |
| Signal-to-Noise Ratio <sup>(2)</sup>              | f <sub>S</sub> = 44.1kHz   | 92      | 100                                  |       | dB               |
|   | f <sub>S</sub> = 96kHz   |         | 97                                   |       | dB               |
| Channel Separation                                | f <sub>S</sub> = 44.1kHz   | 90      | 97                                   |       | dB               |
| <b>DC ACCURACY</b>                                |  |         |                                      |       |                  |
| Gain Error  |  |         | ±1.0                                 | ±5.0  | % of FSR         |
| Gain Mismatch, Channel-to-Channel                 |  |         | ±1.0                                 | ±5.0  | % of FSR         |
| Bipolar Zero Error                                | V <sub>OUT</sub> = V <sub>CC</sub> /2 at BPZ                     |         | ±30                                  |       | mV               |
| <b>ANALOG OUTPUT</b>                              |  |         |                                      |       |                  |
| Output Voltage                                    | Full Scale (0dB)   |         | 0.62 x V <sub>CC</sub>               |       | V <sub>p-p</sub> |
| Center Voltage                                    |  |         | V <sub>CC</sub> /2                   |       | VDC              |
| Load Impedance                                    | AC Load  | 5       |                                      |       | kΩ               |
| <b>DIGITAL FILTER PERFORMANCE</b>                 |  |         |                                      |       |                  |
| Passband  |  |         |                                      | 0.445 | f <sub>S</sub>   |
| Stopband  |  | 0.555   |                                      |       | f <sub>S</sub>   |
| Passband Ripple                                   |  |         |                                      | ±0.17 | dB               |
| Stopband Attenuation                              |  | -35     |                                      |       | dB               |
| Delay Time  |  |         | 11.125/f <sub>S</sub>                |       | sec              |
| <b>INTERNAL ANALOG FILTER</b>                     |  |         |                                      |       |                  |
| -3dB Bandwidth                                    |  |         | 100                                  |       | kHz              |
| Passband Response                                 | f = 20kHz  |         | -0.16                                |       | dB               |
| <b>POWER SUPPLY REQUIREMENTS</b>                  |  |         |                                      |       |                  |
| Voltage Range                                     | V <sub>DD</sub> , V <sub>CC</sub>                                | 4.5     | 5                                    | 5.5   | VDC              |
| Supply Current: I <sub>CC</sub> + I <sub>DD</sub> | V <sub>CC</sub> = V <sub>DD</sub> = 5V, f <sub>S</sub> = 44.1kHz |         | 18                                   | 25    | mA               |
|   | V <sub>CC</sub> = V <sub>DD</sub> = 5V, f <sub>S</sub> = 96kHz   |         | 25                                   | 35    | mA               |
| <b>TEMPERATURE RANGE</b>                          |  |         |                                      |       |                  |
| Operation   |  | -25     |                                      | +85   | °C               |
| Storage   |  | -55     |                                      | +100  | °C               |

NOTES: (1) Dynamic performance specs are tested with 20kHz low pass filter and THD+N specs are tested with 30kHz LPF, 400Hz HPF, Average-Mode. (2) SNR is tested with Infinite Zero Detection off.

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## PIN CONFIGURATION



## PACKAGE INFORMATION

| PRODUCT  | PACKAGE     | PACKAGE DRAWING NUMBER <sup>(1)</sup> |
|----------|-------------|---------------------------------------|
| PCM1726E | 20-Pin SSOP | 334-1                                 |

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book.

## ABSOLUTE MAXIMUM RATINGS

|   |                                   |
|---|-----------------------------------|
| Power Supply Voltage .....                            | +6.5V                             |
| +V <sub>CC</sub> to +V <sub>DD</sub> Difference ..... | ±0.1V                             |
| Input Logic Voltage .....                             | -0.3V to (V <sub>DD</sub> + 0.3V) |
| Power Dissipation .....                               | 300mW                             |
| Operating Temperature Range .....                     | -25°C to +85°C                    |
| Storage Temperature .....                             | -55°C to +125°C                   |
| Lead Temperature (soldering, 5s) .....                | +260°C                            |
| Thermal Resistance, $\theta_{JA}$ .....               | +70°C/W                           |

## PIN ASSIGNMENTS

| PIN               | NAME              | TYPE | FUNCTION   |
|-------------------|-------------------|------|--|
| 1                 | NC                | —    | No Connection.   |
| 2                 | SCKI              | IN   | System Clock Input: 256f <sub>S</sub> or 384f <sub>S</sub> .   |
| 3                 | RES               | —    | Reserved for Factory Use. Do not connect.  |
| 4 <sup>(1)</sup>  | FORMAT            | IN   | Input Data Format Control.   |
| 5 <sup>(1)</sup>  | LRPL              | IN   | Left/Right Polarity Control.   |
| 6 <sup>(1)</sup>  | MUTE              | IN   | Soft Mute Control.   |
| 7 <sup>(1)</sup>  | RSTB              | IN   | Reset Input. When this pin is low, the digital filters and modulators are held in reset.                 |
| 8                 | ZERO              | OUT  | Zero Data Flag. This pin is low when the data is continuously zero for more than 65,535 cycles of BCKIN. |
| 9                 | V <sub>OUTR</sub> | OUT  | Right Channel Analog Output.   |
| 10                | AGND              | PWR  | Analog Ground.   |
| 11                | V <sub>CC</sub>   | PWR  | Analog Power Supply (+5V).   |
| 12                | V <sub>OUTL</sub> | OUT  | Left Channel Analog Output.  |
| 13                | CAP               | —    | Common Pin for Analog Output Amplifiers.   |
| 14 <sup>(1)</sup> | BCKIN             | IN   | Bit Clock for Clocking in the Audio Data.  |
| 15 <sup>(1)</sup> | DIN               | IN   | Serial Audio Data Input.   |
| 16 <sup>(1)</sup> | LRCIN             | IN   | Left/Right Word Clock. Frequency is equal to f <sub>S</sub> .  |
| 17                | TEST              | —    | Must be Tied to Ground.  |
| 18                | RES               | —    | Do Not Connect.  |
| 19                | V <sub>DD</sub>   | PWR  | Digital Power Supply (+5V). Recommended connection is to the analog power supply.                        |
| 20                | DGND              | PWR  | Digital Ground. Recommended connection is to the digital ground plane.                                   |

NOTE: (1) These pins include internal pull-up resistors.



## ELECTROSTATIC DISCHARGE SENSITIVITY

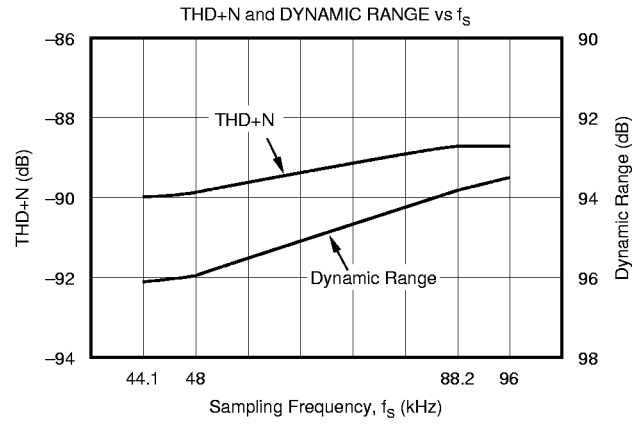
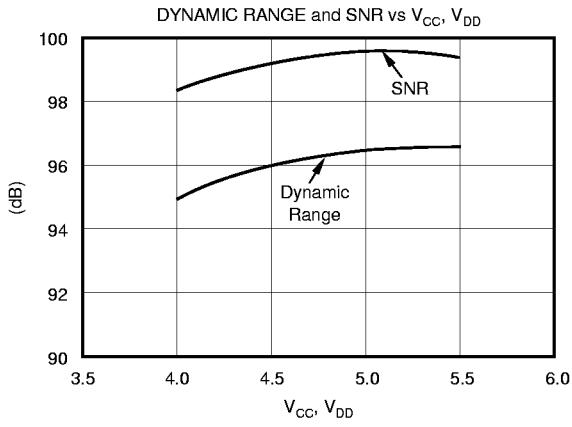
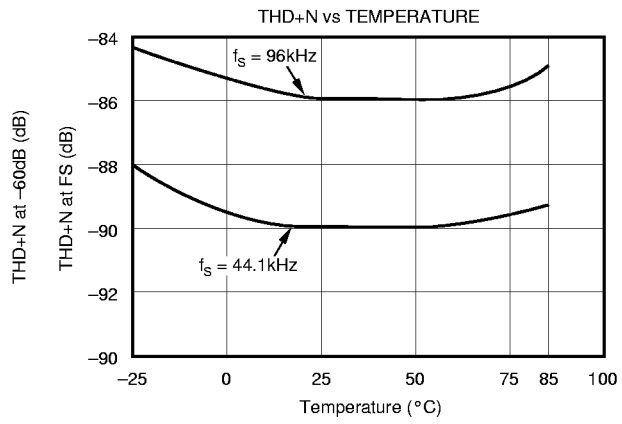
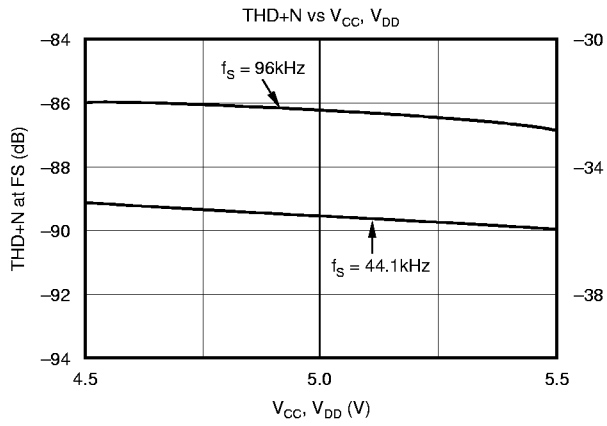
This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

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.

# TYPICAL PERFORMANCE CURVES

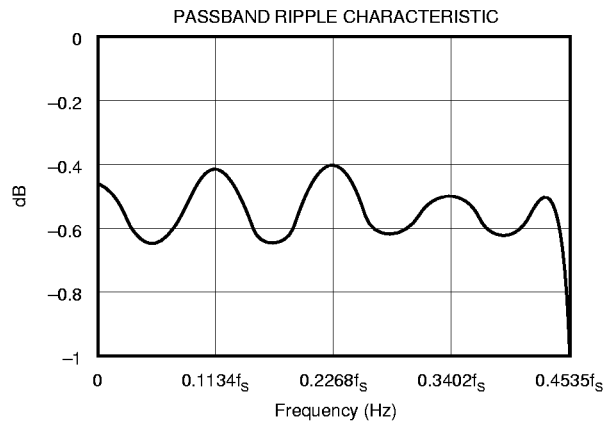
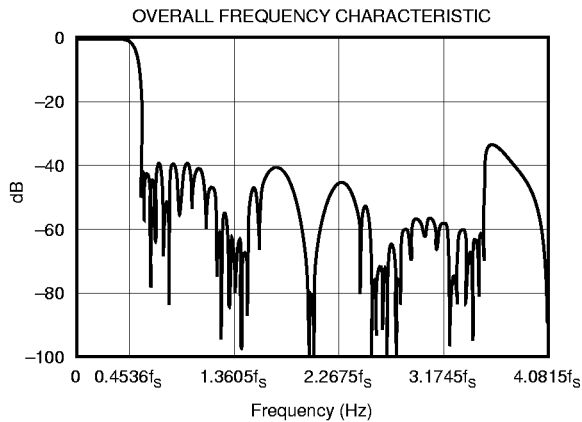
## DYNAMIC PERFORMANCE

At  $T_A = +25^\circ\text{C}$ ,  $V_{CC} = V_{DD} = +5\text{V}$ ,  $f_s = 44.1\text{kHz}$ , 16-bit input data, unless otherwise noted. Measurement bandwidth is 20kHz.



## DIGITAL FILTER

At  $T_A = +25^\circ\text{C}$ ,  $V_{CC} = V_{DD} = +5\text{V}$ ,  $f_s = 44.1\text{kHz}$ ,  $f_{SYS} = 384f_s$ , and 16-bit input data, unless otherwise noted.



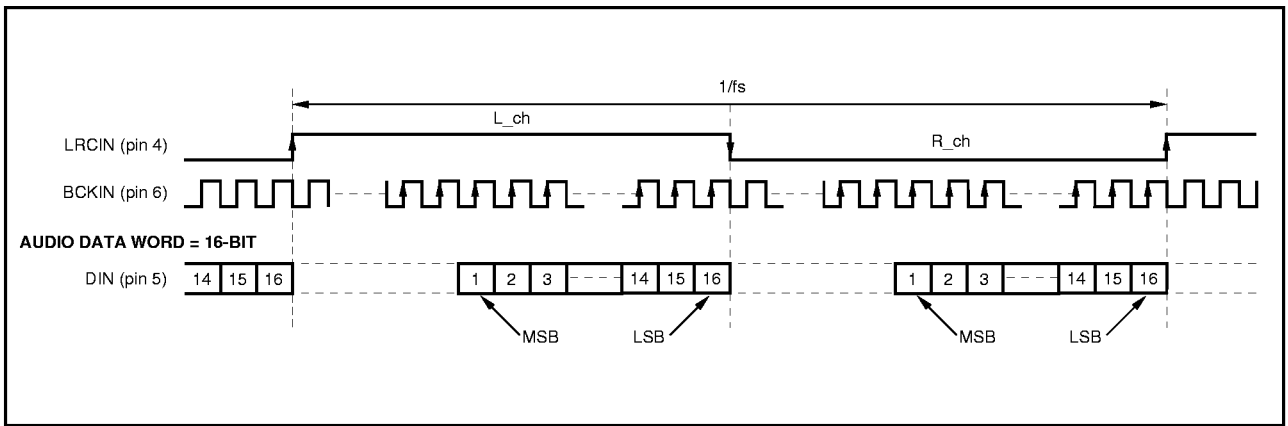


FIGURE 1. "Normal" Data Input Timing.

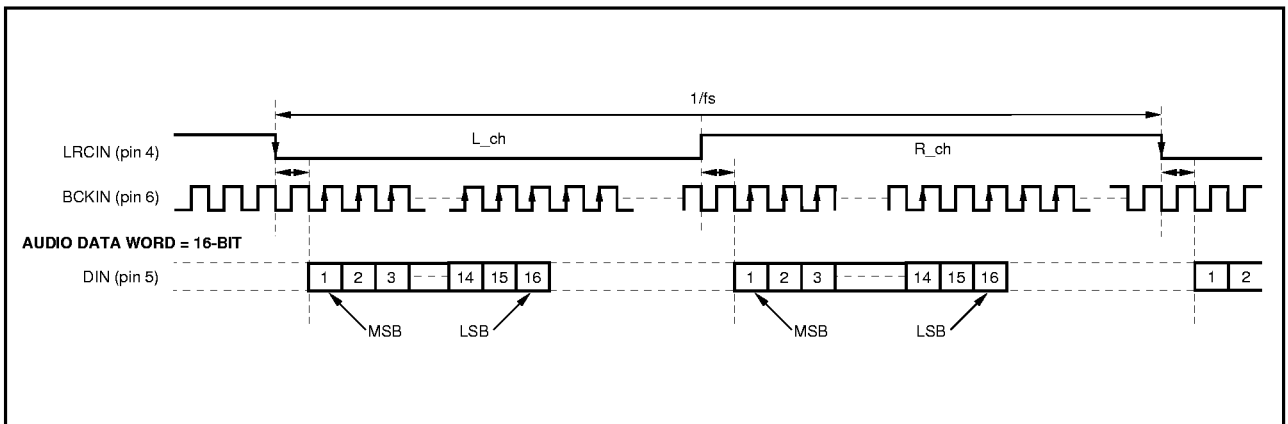


FIGURE 2. "I<sup>2</sup>S" Data Input Timing.

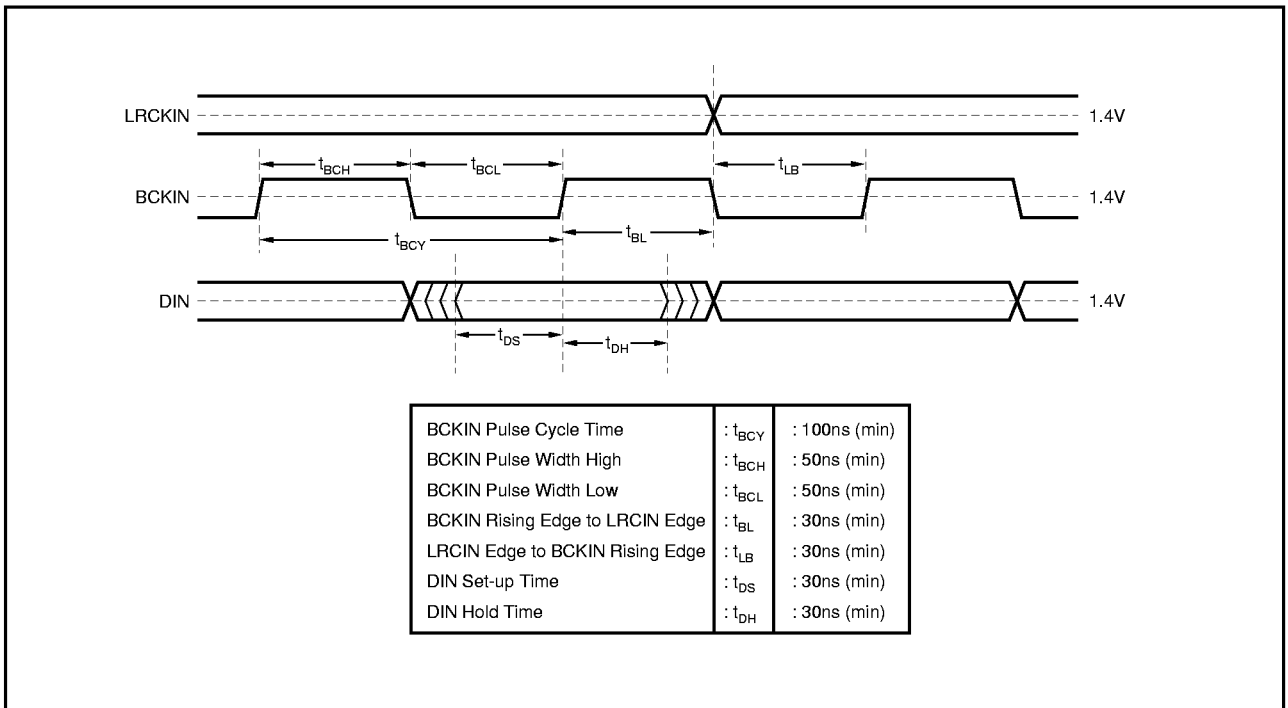


FIGURE 3. Audio Data Input Timing.

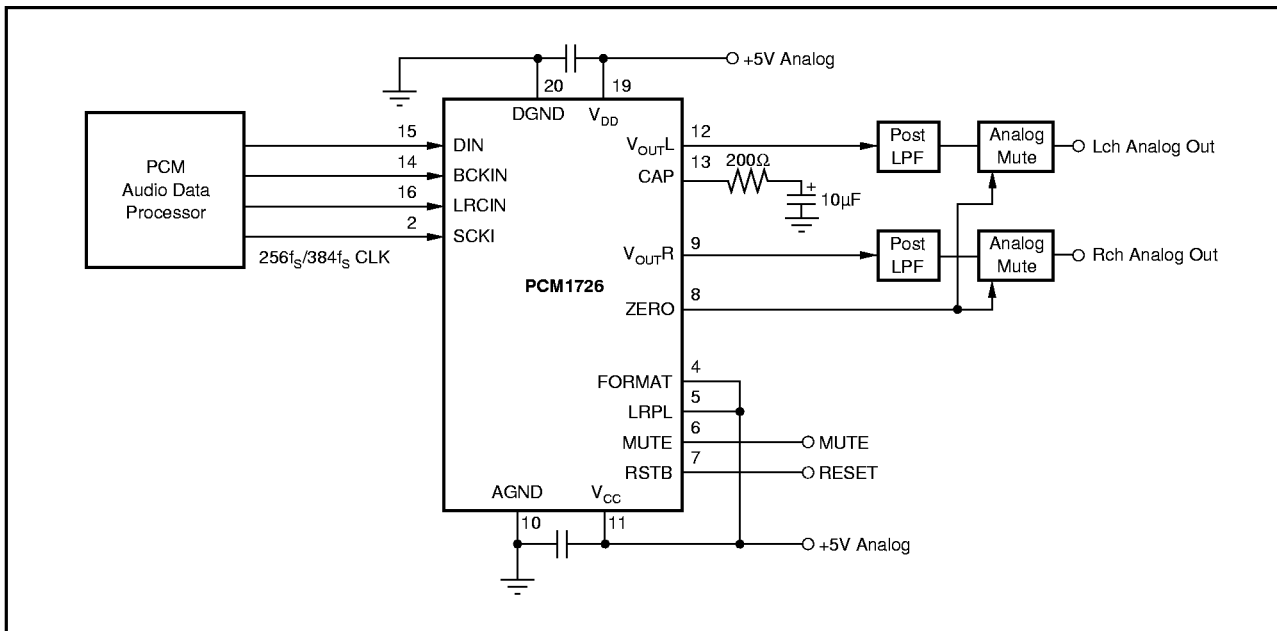


FIGURE 4. Typical Connection Diagram For I<sup>2</sup>S Data Format.

**TYPICAL CONNECTION DIAGRAM**

Figure 4 illustrates the typical connection diagram for PCM1726 used in a stand-alone application.

**SYSTEM CLOCK**

The system clock for PCM1726 must be either 256f<sub>s</sub> or 384f<sub>s</sub>, where f<sub>s</sub> is the audio sampling frequency (LRCIN), typically 32kHz, 44.1kHz or 48kHz. The system clock is used to operate the digital filter and the noise shaper. The system clock input (SCKI) is at pin 2.

PCM1726 has a system clock detection circuit which automatically detects the frequency, either 256f<sub>s</sub> or 384f<sub>s</sub>. The system clock should be synchronized with LRCIN (pin 16), but PCM1726 can compensate for phase differences. If the phase difference between LRCIN and system clock is greater than ±6 bit clocks (BCKIN), the synchronization is performed automatically. The analog outputs are forced to a bipolar zero state (V<sub>CC</sub>/2) during the synchronization function. Table I shows the typical system clock frequency inputs for the PCM1726.

| SAMPLING RATE (LRCIN) | SYSTEM CLOCK FREQUENCY (MHz) |                   |
|-----------------------|------------------------------|-------------------|
|                       | 256f <sub>s</sub>            | 384f <sub>s</sub> |
| 32kHz                 | 8.192                        | 12.288            |
| 44.1kHz               | 11.2896                      | 16.9340           |
| 48kHz                 | 12.288                       | 18.432            |

TABLE I. System Clock Frequencies vs Sampling Rate.

**INPUT DATA FORMAT**

PCM1726 can accept input data in either normal (MSB-first, right-justified) or I<sup>2</sup>S formats. When pin 4 (FORMAT) is LOW, normal data format is selected; a HIGH on pin 4 selects I<sup>2</sup>S format.

| FORMAT |  |
|--------|--|
| 0      | Normal Format (MSB-first, right-justified)             |
| 1      | I <sup>2</sup> S Format (Philips serial data protocol) |

TABLE II. Input Format Selection.

**SOFT MUTE**

The outputs of the PCM1726 can be muted by taking pin 6 (MUTE) to a LOW state. This pin has an internal pull-up resistor and may be left open for non-muted operation of the DAC.

| MUTE |               |
|------|---------------|
| 0    | Soft Mute ON  |
| 1    | Soft Mute OFF |

TABLE III. Soft Mute Enable.

**WORD POLARITY**

The polarity of the input data word (LRCIN) may be controlled by pin 5 (LRPL). A LOW on pin 5 interprets the HIGH portion on LRCIN as left-channel data, and the LOW portion of LRCIN as right-channel data. Taking pin 5 HIGH reverses the polarity.

| LRPL | LRCIN VALUE                                |
|------|--|
| 0    | Left-Channel is HIGH; Right-Channel is LOW |
| 1    | Left-Channel is LOW; Right-Channel is HIGH |

TABLE IV. Left/Right Polarity Selection.

## RESET

PCM1726 has an internal power-on reset circuit, as well as an external forced reset (RSTB, pin 7). The internal power-on reset initializes (resets) when the supply voltage  $V_{DD} > 4.0V$  (typ). External forced reset occurs when  $RSTB = LOW$  and the outputs of the DAC are at  $V_{CC}/2$ . The power-on reset has an initialization period equal to 1024 system clock periods after  $V_{DD} > 4.0V$  and  $RSTB = HIGH$ . During the initialization period, the outputs of the DAC are invalid, and the analog outputs are forced to  $V_{CC}/2$ . Figures 5 and 6 illustrate the power-on reset and reset-pin reset timing.

## APPLICATION CONSIDERATIONS

### DELAY TIME

There is a finite delay time in delta-sigma converters. In A/D converters, this is commonly referred to as latency. For a delta-sigma D/A converter, delay time is determined by the

order number of the FIR filter stage, and the chosen sampling rate. The following equation expresses the delay time of PCM1726:

$$T_D = 11.125 \times 1/f_s$$

$$\text{For } f_s = 44.1\text{kHz, } T_D = 11.125/44.1\text{kHz} = 251.4\mu\text{s}$$

Applications using data from a disc or tape source, such as CD audio, CD-Interactive, Video CD, DAT, Minidisc, etc., generally are not affected by delay time. For some professional applications such as broadcast audio for studios, it is important for total delay time to be less than 2ms.

### OUTPUT FILTERING

For testing purposes all dynamic tests are done on the PCM1726 using a 20kHz low pass filter. This filter limits the measured bandwidth for THD+N, etc. to 20kHz. Failure to use such a filter will result in higher THD+N and lower SNR and Dynamic Range readings than are found in the specifications. The low pass filter removes out of band noise. Although it is not audible, it may affect dynamic specification numbers.

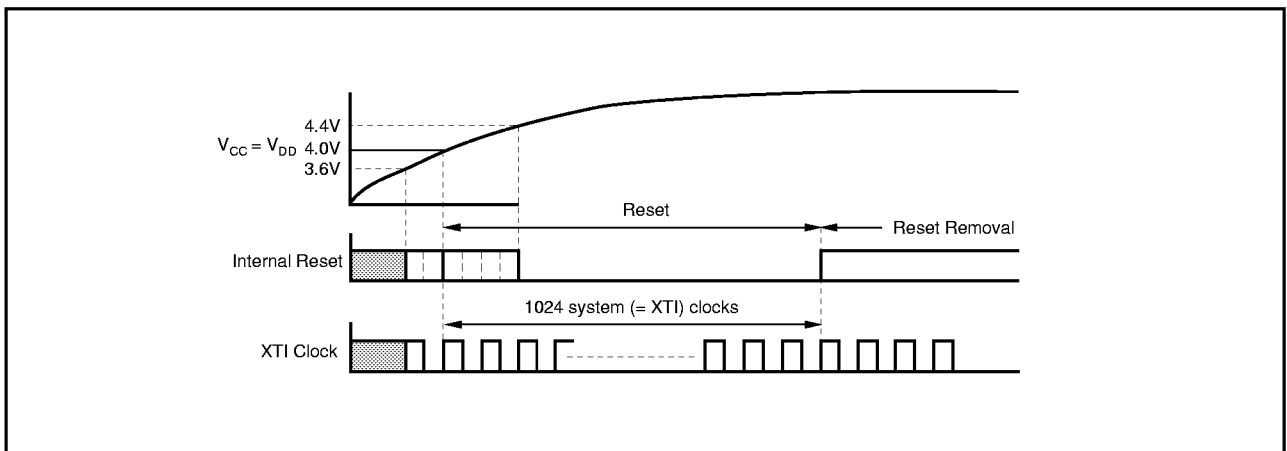


FIGURE 5. Internal Power-On Reset Timing.

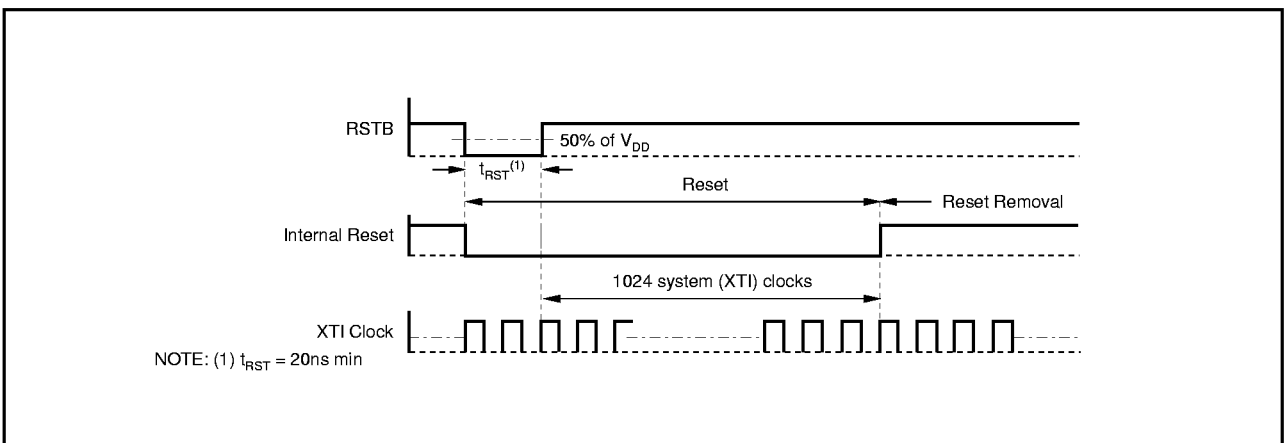


FIGURE 6. External Forced Reset Timing.

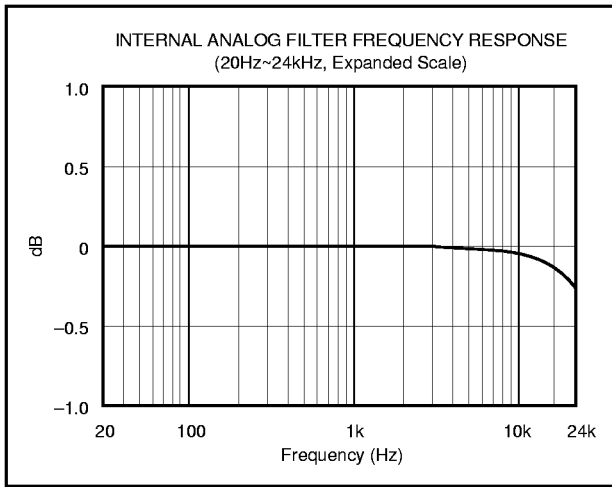


FIGURE 7. Low Pass Filter Frequency Response.

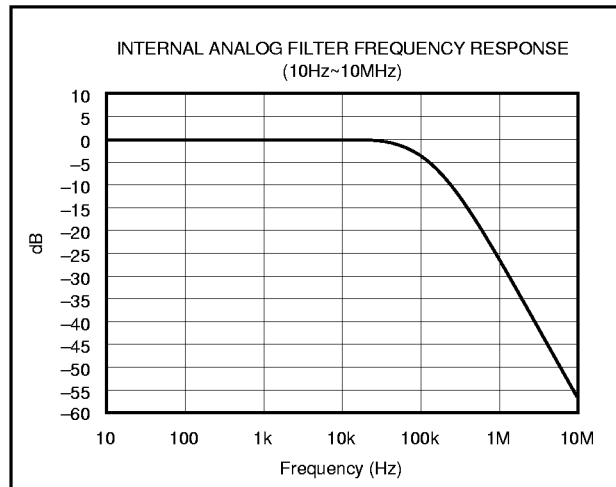


FIGURE 8. Low Pass Filter Wideband Frequency Response.

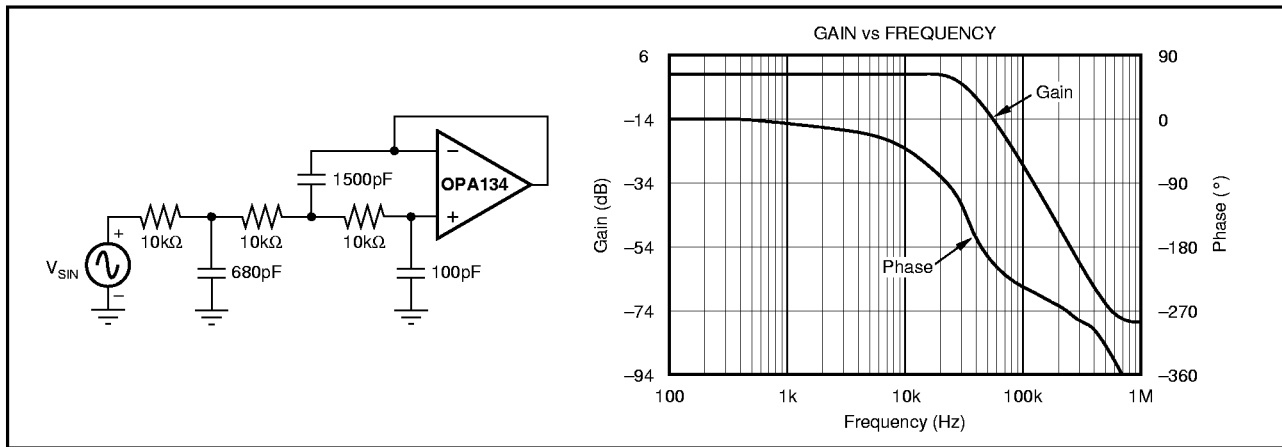


FIGURE 9. 3rd-Order LPF.

The performance of the internal low pass filter from DC to 24kHz is shown in Figure 7. The higher frequency rolloff of the filter is shown in Figure 8. If the user's application has the PCM1726 driving a wideband amplifier, it is recommended to use an external low pass filter. A simple 3rd-order filter is shown in Figure 9. For some applications, a passive RC filter or 2nd-order filter may be adequate.

## POWER SUPPLY CONNECTIONS

PCM1726 has two power supply connections: digital ( $V_{DD}$ ) and analog ( $V_{CC}$ ). Each connection also has a separate ground. If the power supplies turn on at different times, there is a possibility of a latch-up condition. To avoid this condition, it is recommended to have a common connection between the digital and analog power supplies. If separate supplies are used without a common connection, the delta between the two supplies during ramp-up time must be less than 0.6V.

An application circuit to avoid a latch-up condition is shown in Figure 10.

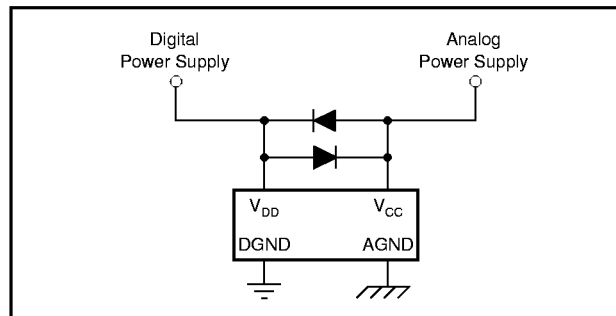


FIGURE 10. Latch-up Prevention Circuit.

## BYPASSING POWER SUPPLIES

The power supplies should be bypassed as close as possible to the unit. It is also recommended to include a 0.1μF ceramic capacitor in parallel with the 10μF tantalum bypass capacitor.



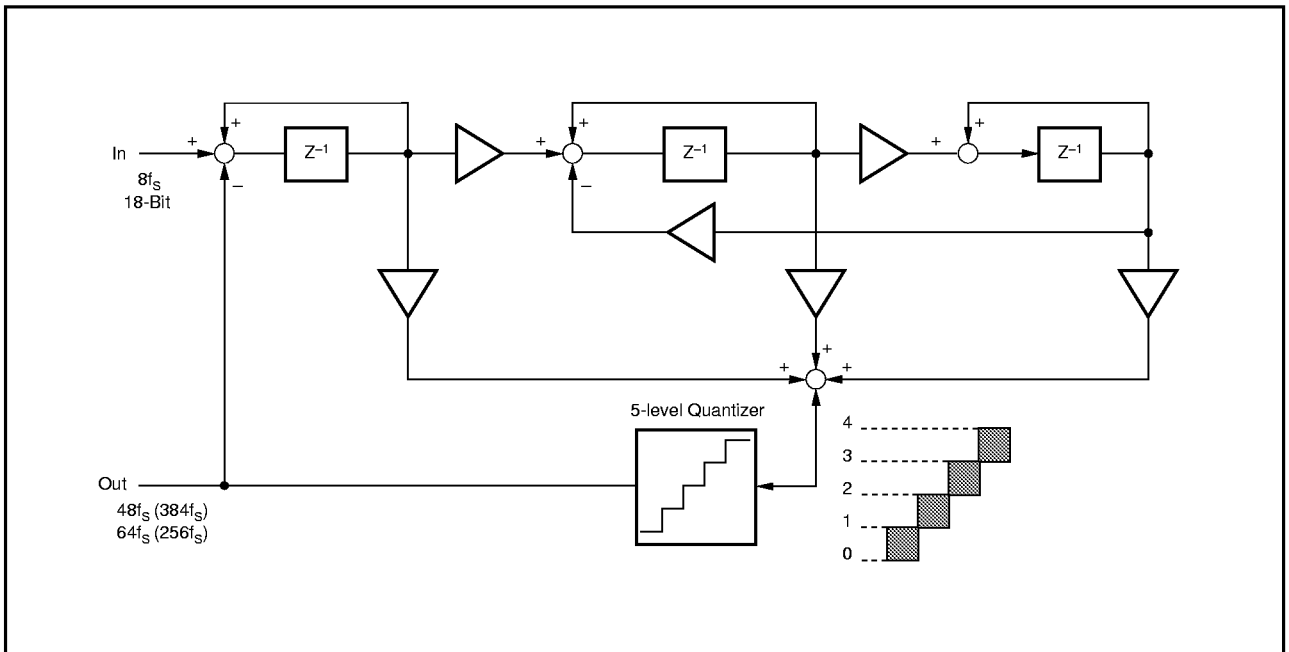


FIGURE 11. 5-Level  $\Delta\Sigma$  Modulator Block Diagram.

## THEORY OF OPERATION

The delta-sigma section of PCM1726 is based on a 5-level amplitude quantizer and a 3rd-order noise shaper. This section converts the oversampled input data to 5-level delta-sigma format. A block diagram of the 5-level delta-sigma modulator is shown in Figure 11. This 5-level delta-sigma modulator has the advantage of stability and clock jitter over the typical one-bit (2-level) delta-sigma modulator.

The combined oversampling rate of the delta-sigma modulator and the internal 8X interpolation filter is  $48f_s$  for a  $384f_s$  system clock, and  $64f_s$  for a  $256f_s$  system clock. The theoretical quantization noise performance of the 5-level delta-sigma modulator is shown in Figure 12.

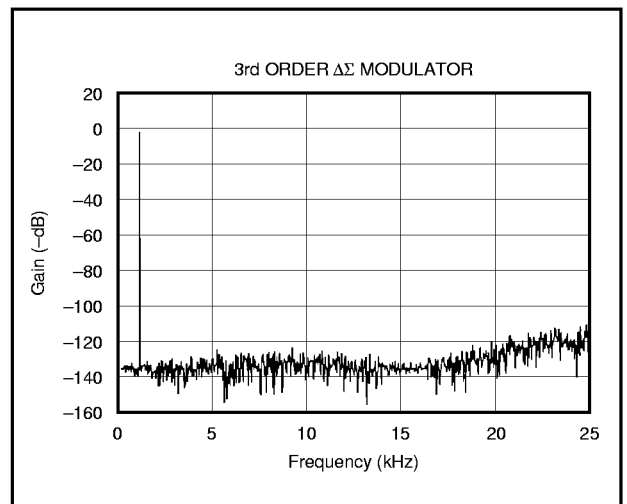
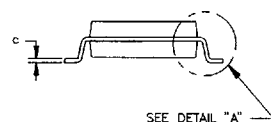
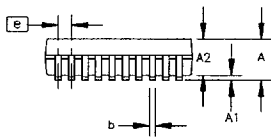
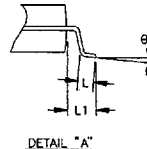
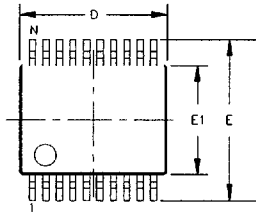


FIGURE 12. Quantization Noise Spectrum.

For Immediate Assistance, Contact Your Local Salesperson

Package Number 334-1 - 20-Lead SSOP

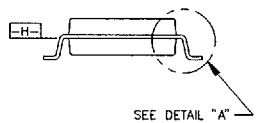
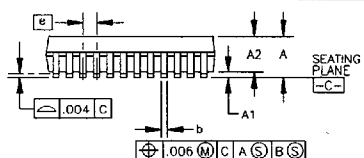
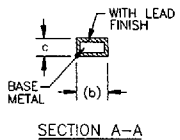
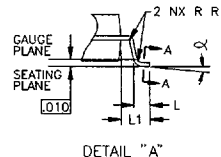
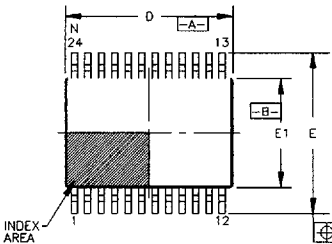


| DIM | INCHES |       | MILLIMETERS |       | N | E | DIM | INCHES |      | MILLIMETERS |      | N | E |
|-----|--------|-------|-------------|-------|---|---|-----|--------|------|-------------|------|---|---|
|     | MIN.   | MAX.  | MIN.        | MAX.  |   |   |     | MIN.   | MAX. | MIN.        | MAX. |   |   |
| A   | --     | .079  | --          | 2.00  |   |   |     |        |      |             |      |   |   |
| A1  | .002   | --    | 0.05        | --    |   |   |     |        |      |             |      |   |   |
| A2  | .065   | .073  | 1.65        | 1.85  |   |   |     |        |      |             |      |   |   |
| b   | .009   | .015  | 0.22        | 0.38  |   |   |     |        |      |             |      |   |   |
| c   | .004   | .010  | 0.09        | 0.25  |   |   |     |        |      |             |      |   |   |
| D   | .272   | .295  | 6.90        | 7.50  |   |   |     |        |      |             |      |   |   |
| E   | .291   | .323  | 7.40        | 8.20  |   |   |     |        |      |             |      |   |   |
| E1  | .196   | .220  | 5.00        | 5.60  |   |   |     |        |      |             |      |   |   |
| e   | .0256  | BASIC | 0.65        | BASIC |   |   |     |        |      |             |      |   |   |
| L   | .018   | .037  | 0.45        | 0.95  |   |   |     |        |      |             |      |   |   |
| L1  | .047   | .055  | 1.20        | 1.40  |   |   |     |        |      |             |      |   |   |
| N   | 20     |       | 20          |       |   |   |     |        |      |             |      |   |   |
| g   | 0'     | 8'    | 0'          | 8'    |   |   |     |        |      |             |      |   |   |

NOTES:

PACKAGE NUMBER: ZZ334-1 REV.: A  
JEDEC NUMBER: NONE

Package Number 338 - 24-Lead SSOP, .209 Wide



| DIM | INCHES |       | MILLIMETERS |       | N   | E | DIM | INCHES |      | MILLIMETERS |      | N | E |
|-----|--------|-------|-------------|-------|-----|---|-----|--------|------|-------------|------|---|---|
|     | MIN.   | MAX.  | MIN.        | MAX.  |     |   |     | MIN.   | MAX. | MIN.        | MAX. |   |   |
| A   | --     | .079  | --          | 2.00  |     |   |     |        |      |             |      |   |   |
| A1  | .002   | --    | 0.05        | --    |     |   |     |        |      |             |      |   |   |
| A2  | .065   | .073  | 1.65        | 1.85  |     |   |     |        |      |             |      |   |   |
| b   | .009   | .015  | 0.22        | 0.38  | 3,7 |   |     |        |      |             |      |   |   |
| c   | .004   | .010  | 0.09        | 0.25  | 7   |   |     |        |      |             |      |   |   |
| D   | .311   | .335  | 7.90        | 8.50  | 2   |   |     |        |      |             |      |   |   |
| E   | .291   | .323  | 7.40        | 8.20  |     |   |     |        |      |             |      |   |   |
| E1  | .197   | .220  | 5.00        | 5.60  | 2   |   |     |        |      |             |      |   |   |
| e   | .0256  | BASIC | 0.65        | BASIC |     |   |     |        |      |             |      |   |   |
| L   | .022   | .037  | 0.55        | 0.95  | 4   |   |     |        |      |             |      |   |   |
| L1  | .049   | REF   | 1.25        | REF   |     |   |     |        |      |             |      |   |   |
| N   | 24     |       | 24          |       | 5   |   |     |        |      |             |      |   |   |
| <   | 0'     | 8'    | 0'          | 8'    |     |   |     |        |      |             |      |   |   |
| R1  | .004   | --    | 0.09        | --    |     |   |     |        |      |             |      |   |   |

NOTES:

- DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
- D AND E1 DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS, BUT DO INCLUDE MOLD MISMATCH AND ARE MEASURED AT DATUM PLANE "C". MOLD PARTING LINE. MOLD FLASH OR PROTRUSION SHALL NOT EXCEED .008 INCH (0.20mm) PER SIDE.
- DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION/INTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 INCH (0.13mm) TOTAL IN EXCESS OF b DIMENSION AT MAXIMUM MATERIAL CONDITION.

DAMBAR INTRUSION SHALL NOT REDUCE DIMENSION b BY MORE THAN .003 INCH (0.07mm) AT LEAST MATERIAL CONDITION.

- DIMENSION L TO BE DETERMINED AT SEATING PLANE-DATUM "C".
- N IS THE NUMBER OF TERMINAL POSITIONS.
- A VISUAL INDEX FEATURE MUST BE LOCATED WITHIN THE CROSSHATCHED AREA.
- SECTION A-A DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN .004 AND .010 INCH FROM THE LEAD TIP.

PACKAGE NUMBER: ZZ338 REV.: A  
JEDEC NUMBER: MO-150-AG

