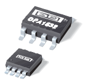
Burr-Brown Products
from Texas Instruments

OPA1632



SBOS286 − DECEMBER 2003

High-Perfomance, Fully-Differential AUDIO OP AMP

FEATURES

- **SUPERIOR SOUND QUALITY**
- **ULTRA LOW DISTORTION: 0.000022%**
- **LOW NOISE: 1.3nV/√Hz**
- **HIGH SPEED:**
  - **Slew Rate: 50V/µs**
  - **Gain Bandwidth: 180MHz**
- **FULLY DIFFERENTIAL ARCHITECTURE:**
  - **Balanced Input and Output Converts Single-Ended Input to Balanced Differential Output**
- **WIDE SUPPLY RANGE: ±2.5V to ±16V**
- **SHUTDOWN TO CONSERVE POWER**

APPLICATIONS

- **AUDIO ADC DRIVER**
- **BALANCED LINE DRIVER**
- **BALANCED RECEIVER**
- **ACTIVE FILTER**
- **PREAMPLIFIER**

DESCRIPTION

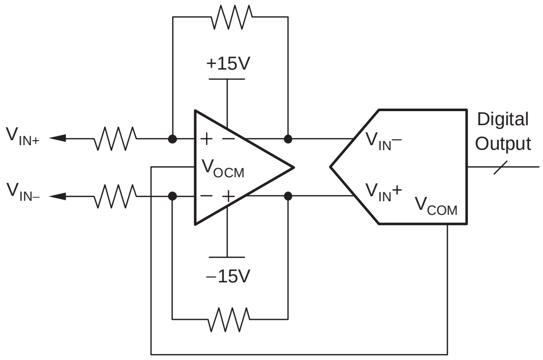
The OPA1632 is a fully-differential amplifier designed for driving high-performance audio analog-to-digital converters (ADCs). It provides the highest audio quality, with very low noise and output drive characteristics optimized for this application. The OPA1632's excellent gain bandwidth of 180MHz and very fast slew rate of 50V/µs produce exceptionally low distortion. Very low input noise of 1.3nV/√Hz further ensures maximum signal-to-noise ratio and dynamic range.

The flexibility of the fully differential architecture allows for easy implementation of a single-ended to fully-differential output conversion. Differential output reduces even-order harmonics and minimizes common-mode noise interference. The OPA1632 provides excellent performance when used to drive high-performance audio ADCs such as the PCM1804. A shutdown feature also enhances the flexibility of this amplifier.

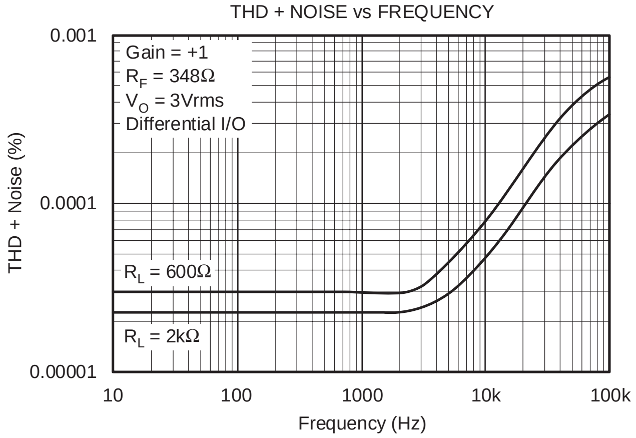
The OPA1632 is available in an SO-8 package and a thermally-enhanced MSOP-8 PowerPAD package.

RELATED DEVICES

OPAx134	High-Performance Audio Amplifiers
OPA627/637	Precision High-Speed DiFET Amplifiers
OPAx227/x228	Low-Noise Bipolar Amplifiers



Typical ADC Circuit



TEXAS INSTRUMENTS
www.ti.com

PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE-LEAD(1)	PACKAGE DRAWING	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
OPA1632	SO-8	D	−40°C to +85°C	OPA1632	OPA1632D	Rails, 100
					OPA1632DR	Tape and Reel, 2500
	MSOP-8 PowerPAD	DGN	−40°C to +85°C	1632	OPA1632DGN	Rails, 100
					OPA1632DGNR	Tape and Reel, 2500

(1) For the most current specification and package information, refer to our web site at www.ti.com.

ABSOLUTE MAXIMUM RATINGS(1)(2)

over operating free-air temperature range unless otherwise noted.

Supply Voltage, $\pm V_S$	±16.5V
Input Voltage, V_I	$\pm V_S$
Output Current, I_O	150mA
Differential Input Voltage, V_{ID}	±3V
Maximum Junction Temperature, T_J	150°C
Operating Free-Air Temperature Range	−40°C to +85°C
Storage Temperature Range, T_{STG}	−65°C to +150°C
Lead Temperature 1,6mm (1/16th inch) from case for 10 seconds	+300°C
ESD Ratings: Human Body Model	1kV
Charge Device Model	500V
Machine Model	200V

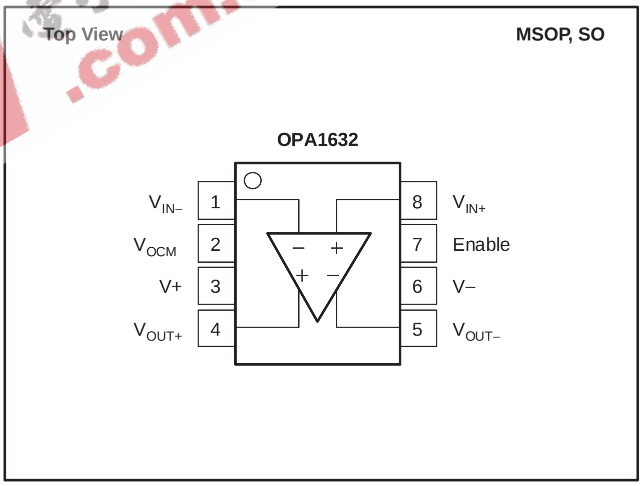
(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

(2) The OPA1632 MSOP-8 package version incorporates a PowerPAD on the underside of the chip. This acts as a heatsink and must be connected to a thermally dissipative plane for proper power dissipation. Failure to do so may result in exceeding the maximum junction temperature, which can permanently damage the device. See TI technical brief SLMA002 for more information about using the PowerPAD thermally enhanced package.

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.

PIN CONFIGURATION



ELECTRICAL CHARACTERISTICS: $V_S = \pm 15V$

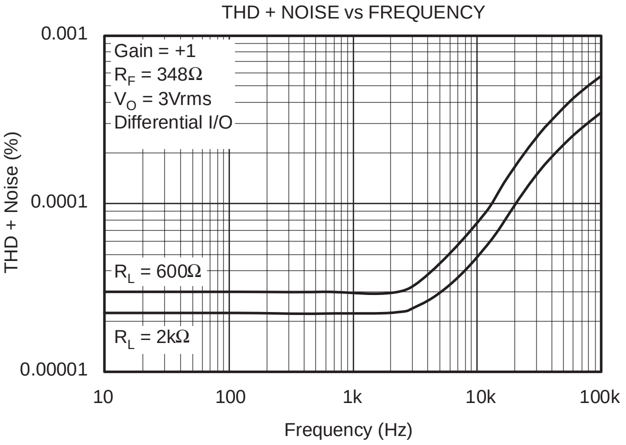
$V_S = \pm 15V$: $R_F = 390\Omega$, $R_L = 800\Omega$, and G = +1, unless otherwise noted.

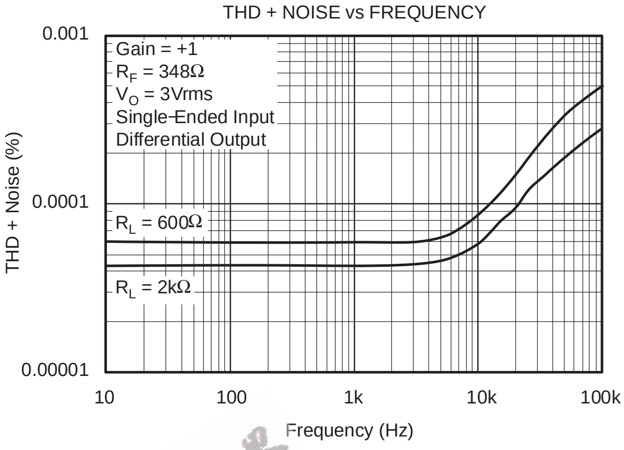
PARAMETER		CONDITIONS	OPA1632			UNITS
			MIN	TYP	MAX	
OFFSET VOLTAGE						
Input Offset Voltage				±0.5	±3	mV
vs Temperature	dVos/dT			±5		μV/°C
vs Power Supply, DC	PSRR		316	13		μV/V
INPUT BIAS CURRENT						
Input Bias Current	I_B			2	6	μA
Input Offset Current	I_{OS}			±100	±500	nA
NOISE						
Input Voltage Noise		f = 10 kHz		1.3		nV/√Hz
Input Current Noise		f = 10 kHz		0.4		pA/√Hz
INPUT VOLTAGE						
Common-Mode Input Range			(V−) + 1.5		(V+) − 1	V
Common-Mode Rejection Ratio, DC			74	90		dB
INPUT IMPEDANCE						
Input Impedance (each input pin)				34 || 4		MΩ || pF
OPEN-LOOP GAIN						
Open-Loop Gain , DC			66	78		dB
FREQUENCY RESPONSE						
Small-Signal Bandwidth		G = +1, R_F= 348Ω		180		MHz
(V_O = 100mV_{PP}, Peaking < 0.5 dB)		G = +2, R_F = 602Ω		90		MHz
		G = +5, R_F = 1.5kΩ		36		MHz
		G = +10, R_F = 3.01kΩ		18		MHz
Bandwidth for 0.1dB Flatness		G = +1, V_O = 100mV_{PP}		40		MHz
Peaking at a Gain of 1		V_O = 100mV_{PP}		0.5		dB
Large-Signal Bandwidth		G = +2, V_O = 20V_{PP}		800		kHz
Slew Rate (25% to 75%)		G = +1		50		V/μs
Rise and Fall Time		G = +1, V_O = 5V Step		100		ns
Settling Time to 0.1%		G = +1, V_O = 2V Step		75		ns
0.01%		G = +1, V_O = 2V Step		200		ns
Total Harmonic Distortion + Noise		G = +1, f = 1kHz, V_O = 3Vrms				
Differential Input/Output		R_L = 600Ω		0.0003		%
Differential Input/Output		R_L = 2kΩ		0.000022		%
Single-Ended In/Differential Out		R_L = 600Ω		0.000059		%
Single-Ended In/Differential Out		R_L = 2kΩ		0.000043		%
Intermodulation Distortion		G = +1, SMPTE/DIN, V_O = 2V_{PP}				
Differential Input/Output		R_L = 600Ω		0.00008		%
Differential Input/Output		R_L = 2kΩ		0.00005		%
Single-Ended In/Differential Out		R_L = 600Ω		0.0001		%
Single-Ended In/Differential Out		R_L = 2kΩ		0.0007		%
Headroom		THD < 0.01%, R_L = 2kΩ		20.0		V_{PP}
OUTPUT						
Voltage Output Swing		R_L = 2kΩ	(V+) − 1.9		(V−) + 1.9	V
		R_L = 800Ω	(V+) − 4.5		(V−) + 4.5	V
Short-Circuit Current	I_{SC}	Sourcing/Sinking	+50/−60	85		mA
Closed-Loop Output Impedance		G = +1, f = 100kHz		0.3		Ω
POWER-DOWN(1)						
Enable Voltage Threshold				(V−) + 2		V
Disable Voltage Threshold				(V−) + 0.8		V
Shutdown Current		V_{ENABLE} = −15V		0.85	1.5	mA
Turn-On Delay		Time for I_Q to Reach 50%		2		μs
Turn-Off Delay		Time for I_Q to Reach 50%		2		μs
POWER SUPPLY						
Specified Operating Voltage				±15	±16	V
Operating Voltage			±2.5			V
Quiescent Current	I_Q	Per Channel		14	17.1	mA
TEMPERATURE RANGE						
Specified Range			−40		+85	°C
Operating Range			−40		+125	°C
Storage Range			−65		+150	°C
Thermal Resistance	θ_{JA}			200		°C/W

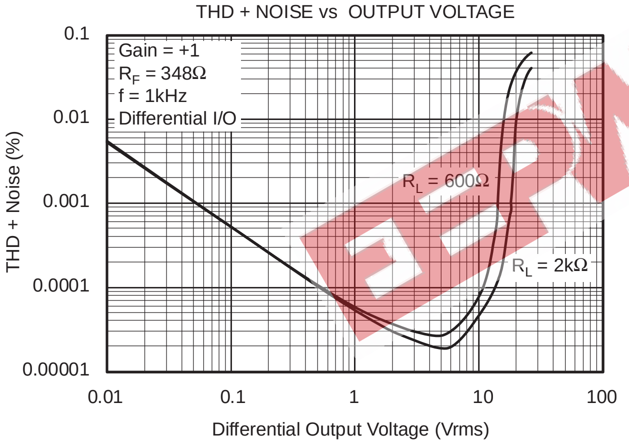
(1) Amplifier has internal 50kΩ pull-up resistor to V_{CC+} pin. This enables the amplifier with no connection to shutdown pin.

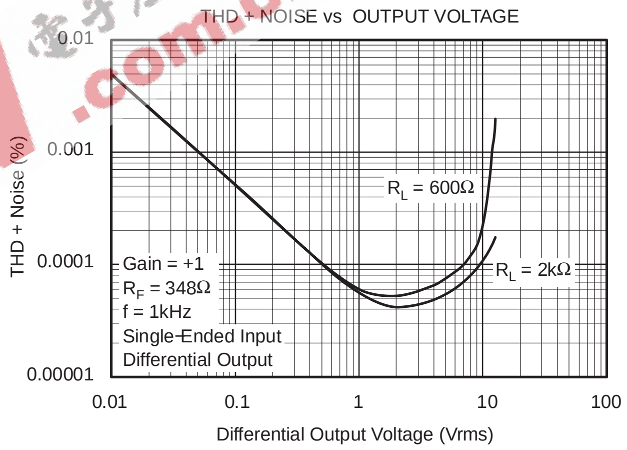
TYPICAL CHARACTERISTICS

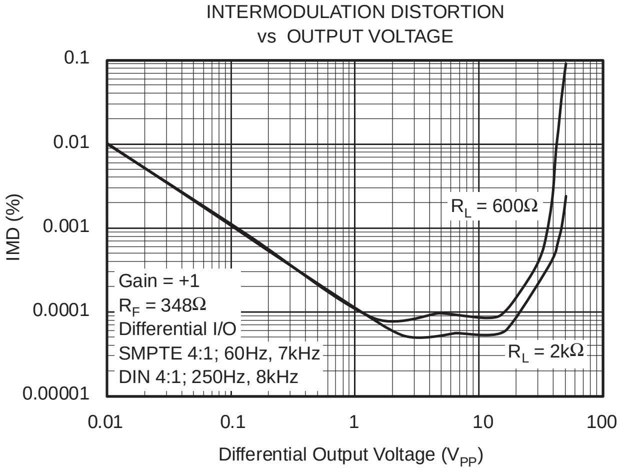
At T_A = +25°C, V_S = ±15V, and R_L = 2kΩ, unless otherwise noted.

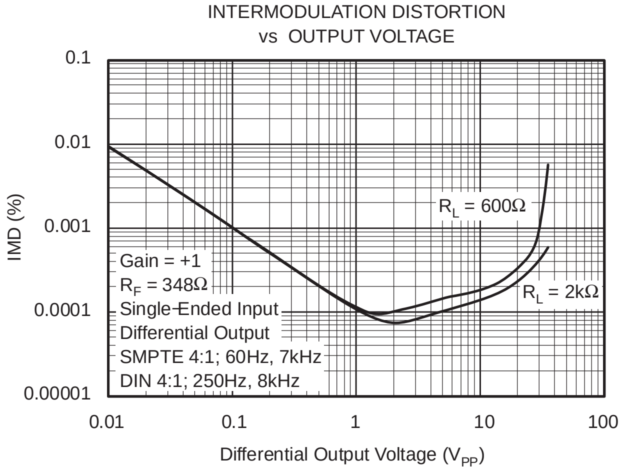








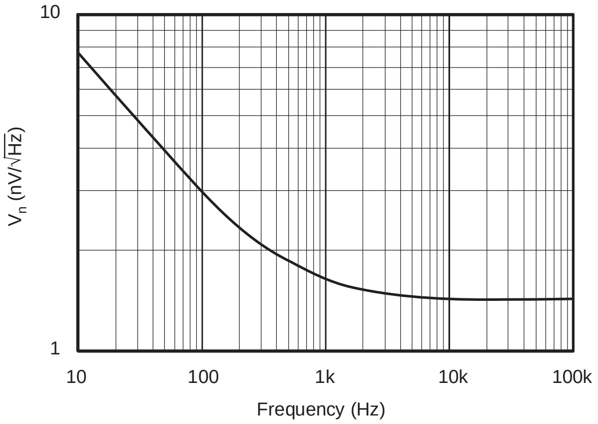




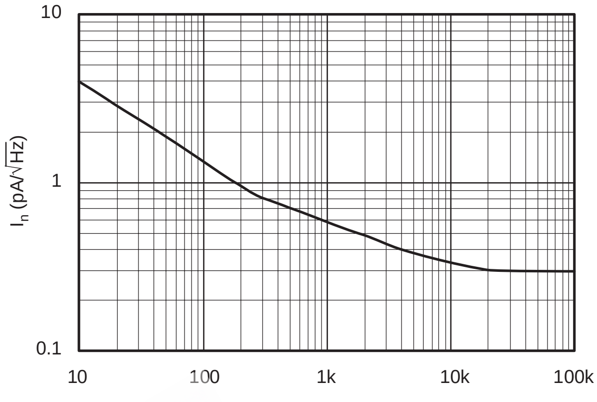
TYPICAL CHARACTERISTICS (Cont.)

At T_A = +25°C, V_S = ±15V, and R_L = 2kΩ, unless otherwise noted.

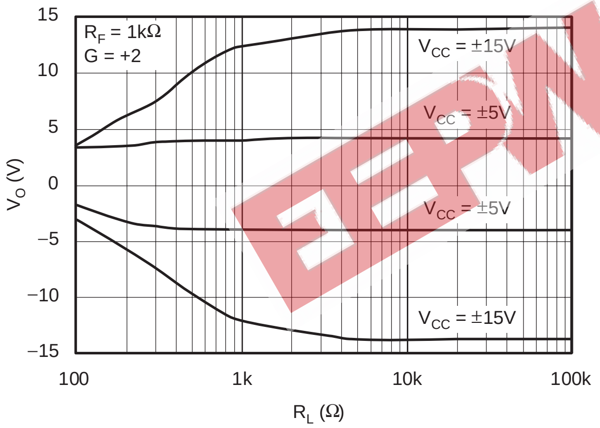
VOLTAGE NOISE vs FREQUENCY



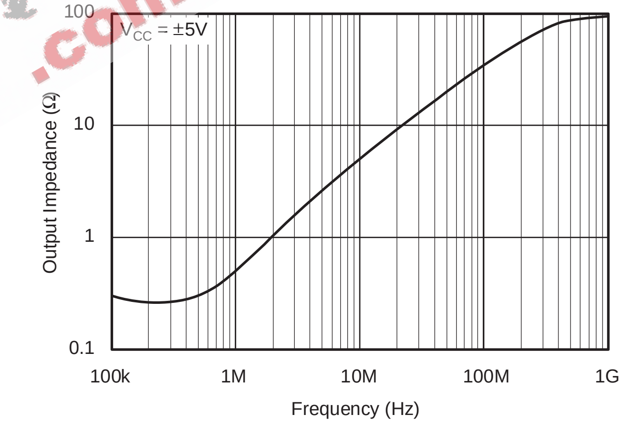
CURRENT NOISE vs FREQUENCY



OUTPUT VOLTAGE
vs DIFFERENTIAL LOAD RESISTANCE



OUTPUT IMPEDANCE
vs FREQUENCY



APPLICATIONS INFORMATION

Figure 1 shows the OPA1632 used as a differential-output driver for the PCM1804 high-performance audio ADC.

Supply voltages of ±15V are commonly used for the OPA1632. The relatively low input voltage swing required by the ADC allows use of lower power-supply voltage, if desired. Power supplies as low as ±8V can be used in this application with excellent performance. This reduces power dissipation and heat rise. Power supplies should be bypassed with 10µF tantalum capacitors in parallel with 0.1µF ceramic capacitors to avoid possible oscillations and instability.

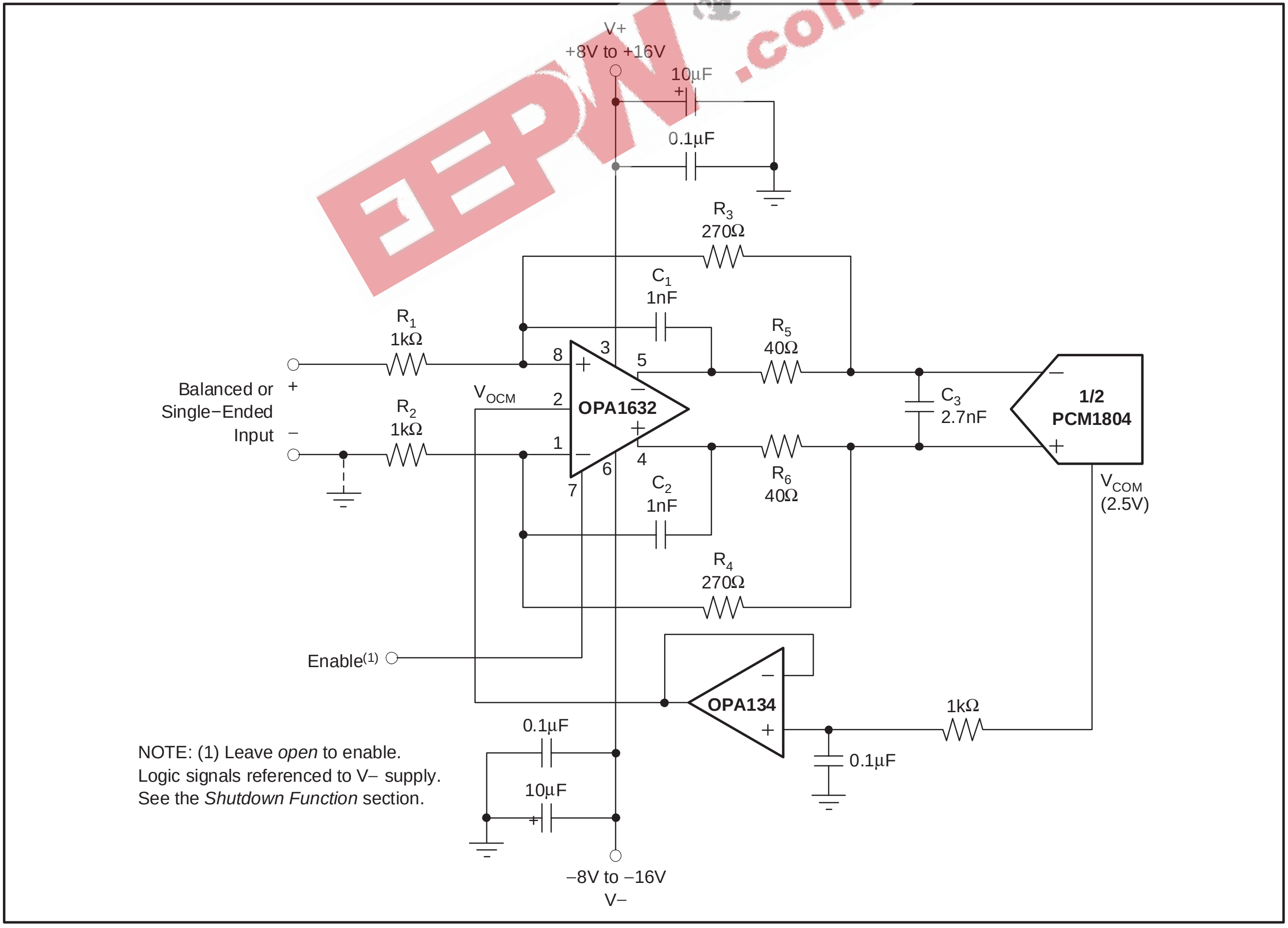
The V_{COM} reference voltage output on the PCM1804 ADC provides the proper input common-mode reference voltage (2.5V). This V_{COM} voltage is buffered with op amp A_2 and drives the output common-mode voltage pin of the OPA1632. This biases the average output voltage of the OPA1632 to 2.5V.

The signal gain of the circuit is generally set to approximately 0.25 to be compatible with commonly-used audio line levels. Gain can be adjusted, if necessary, by changing the values of R_1 and R_2. The feedback resistor values (R_3 and R_4) should be kept relatively low, as indicated, for best noise performance.

R_5, R_6, and C_3 provide an input filter and charge glitch reservoir for the ADC. The values shown are generally satisfactory. Some adjustment of the values may help optimize performance with different ADCs.

It is important to maintain accurate resistor matching on R_1/R_2 and R_3/R_4 to achieve good differential signal balance. Use 1% resistors for highest performance. When connected for single-ended inputs (inverting input grounded, as shown in Figure 1), the source impedance must be low. Differential input sources must have well-balanced or low source impedance.

Capacitors C_1, C_2, and C_3 should be chosen carefully for good distortion performance. Polystyrene, polypropylene, NPO ceramic, and mica types are generally excellent. Polyester and high-K ceramic types such as Z5U can create distortion.



NOTE: (1) Leave *open* to enable.
Logic signals referenced to V− supply.
See the *Shutdown Function* section.

Figure 1. ADC Driver for Professional Audio

FULLY-DIFFERENTIAL AMPLIFIERS

Differential signal processing offers a number of performance advantages in high-speed analog signal processing systems, including immunity to external common-mode noise, suppression of even-order nonlinearities, and increased dynamic range. Fully-differential amplifiers not only serve as the primary means of providing gain to a differential signal chain, but also provide a monolithic solution for converting single-ended signals into differential signals allowing for easy, high-performance processing.

A standard configuration for the device is shown in Figure 2. The functionality of a fully differential amplifier can be imagined as two inverting amplifiers that share a common noninverting terminal (though the voltage is not necessarily fixed). For more information on the basic theory of operation for fully differential amplifiers, refer to the Texas Instruments application note SLOA054, *Fully Differential Amplifiers*, available for download from the TI web site (www.ti.com).

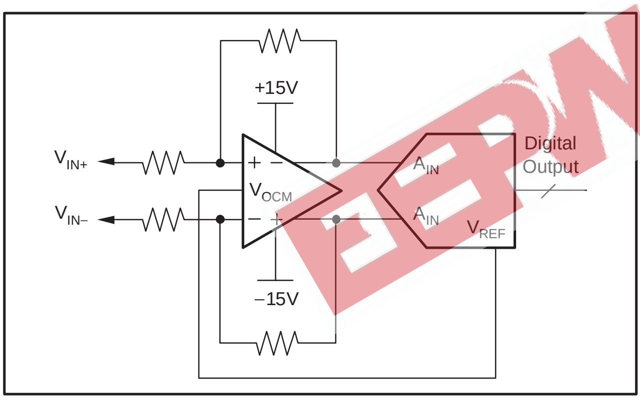


Figure 2. Typical ADC Circuit

SHUTDOWN FUNCTION

The shutdown (enable) function of the OPA1632 is referenced to the negative supply of the operational amplifier. A valid logic low (< 0.8V above negative supply) applied to the enable pin (pin 7) disables the amplifier output. Voltages applied to pin 7 that are greater than 2V above the negative supply place the amplifier output in an active state, and the device is enabled. If pin 7 is left disconnected, an internal pull-up resistor enables the device. Turn-on and turn-off times are approximately 2µs each.

Quiescent current is reduced to approximately 0.85mA when the amplifier is disabled. When disabled, the output stage *is not* in a high-impedance state. Thus, the shutdown function *cannot* be used to create a multiplexed switching function in series with multiple amplifiers.

OUTPUT COMMON-MODE VOLTAGE

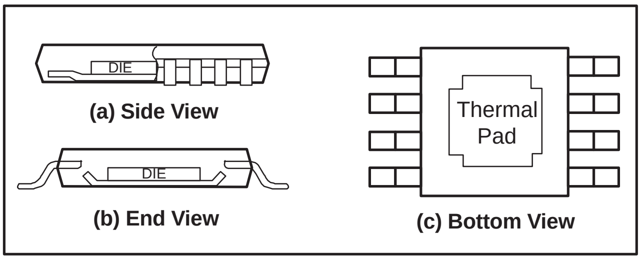
The output common-mode voltage pin sets the DC output voltage of the OPA1632. A voltage applied to the V_{OCM} pin from a low-impedance source can be used to directly set the output common-mode voltage. For a V_{OCM} voltage at mid-supply, make no connection to the V_{OCM} pin.

Depending on the intended application, a decoupling capacitor is recommended on the V_{OCM} node to filter any high-frequency noise that could couple into the signal path through the V_{OCM} circuitry. A 0.1µF or 1µF capacitor is generally adequate.

Output common-mode voltage causes additional current to flow in the feedback resistor network. Since this current is supplied by the output stage of the amplifier, this creates additional power dissipation. For commonly-used feedback resistance values, this current is easily supplied by the amplifier. The additional internal power dissipation created by this current may be significant in some applications and may dictate use of the MSOP PowerPAD package to effectively control self-heating.

PowerPAD DESIGN CONSIDERATIONS

The OPA1632 is available in a thermally-enhanced PowerPAD family of packages. These packages are constructed using a downset leadframe upon which the die is mounted (see Figure 3[a] and Figure 3[b]). This arrangement results in the lead frame being exposed as a thermal pad on the underside of the package (see Figure 3[c]). Because this thermal pad has direct thermal contact with the die, excellent thermal performance can be achieved by providing a good thermal path away from the thermal pad.



(a) Side View

(b) End View

(c) Bottom View

Figure 3. Views of the Thermally-Enhanced Package.

The PowerPAD package allows for both assembly and thermal management in one manufacturing operation. During the surface-mount solder operation (when the leads are being soldered), the thermal pad can also be soldered to a copper area underneath the package. Through the use of thermal paths within this copper area, heat can be conducted away from the package into either a ground plane or other heat-dissipating device.

PowerPAD PCB LAYOUT CONSIDERATIONS

1. Prepare the printed circuit board (PCB) with a top-side etch pattern, as shown in Figure 4. There should be etch for the leads as well as etch for the thermal pad.

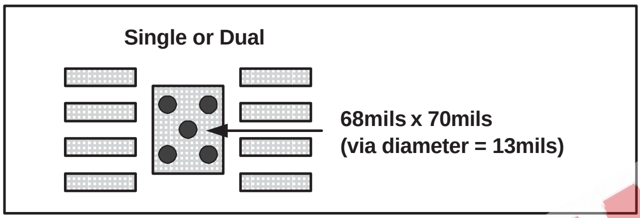


Figure 4. PowerPAD PCB Etch and Via Pattern.

2. Place five holes in the area of the thermal pad. These holes should be 13mils in diameter. Keep them small so that solder wicking through the holes is not a problem during reflow.
3. Additional vias may be placed anywhere along the thermal plane outside of the thermal pad area. These vias help dissipate the heat generated by the OPA1632 IC, and may be larger than the 13mil diameter vias directly under the thermal pad. They can be larger because they are not in the thermal pad area to be soldered so that wicking is not a problem.
4. Connect all holes to the internal ground plane.
5. When connecting these holes to the ground plane, *do not* use the typical web or spoke via connection methodology. Web connections have a high thermal resistance connection that is useful for slowing the heat transfer during soldering operations. This makes the soldering of vias that have plane connections easier. In this application, however, low thermal resistance is desired for the most efficient heat transfer. Therefore, the holes under the OPA1632 PowerPAD package should make their connection to the internal ground plane with a complete connection around the entire circumference of the plated-through hole.
6. The top-side solder mask should leave the terminals of the package and the thermal pad area with its five holes exposed. The bottom-side solder mask should cover the five holes of the thermal pad area. This prevents solder from being pulled away from the thermal pad area during the reflow process.
7. Apply solder paste to the exposed thermal-pad area and all of the IC terminals.
8. With these preparatory steps in place, the IC is simply placed in position and runs through the solder reflow operation as any standard surface-mount component. This results in a part that is properly installed.

POWER DISSIPATION AND THERMAL CONSIDERATIONS

The OPA1632 does not have thermal shutdown protection. Take care to assure that the maximum junction temperature is not exceeded. Excessive junction temperature can degrade performance or cause permanent damage. For best performance and reliability, assure that the junction temperature does not exceed 125°C.

The thermal characteristics of the device are dictated by the package and the circuit board. Maximum power dissipation for a given package can be calculated using the following formula:

$$P_{Dmax} = \frac{T_{\max} - T_A}{\theta_{JA}} \qquad (1)$$

Where:

P_{Dmax} is the maximum power dissipation in the amplifier (W).

T_{max} is the absolute maximum junction temperature (°C).

T_A is the ambient temperature (°C).

$\theta_{JA} = \theta_{JC} + \theta_{CA}$.

θ_{JC} is the thermal coefficient from the silicon junctions to the case (°C/W).

θ_{CA} is the thermal coefficient from the case to ambient air (°C/W).

For systems where heat dissipation is more critical, the OPA1632 is offered in an MSOP-8 with PowerPAD. The thermal coefficient for the MSOP PowerPAD (DGN) package is substantially improved over the traditional SO package. Maximum power dissipation levels are depicted in Figure 5 for the two packages. The data for the DGN package assumes a board layout that follows the PowerPAD layout guidelines.

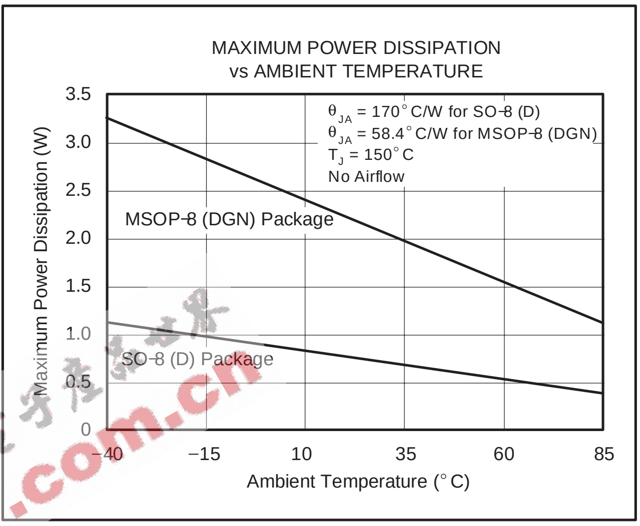
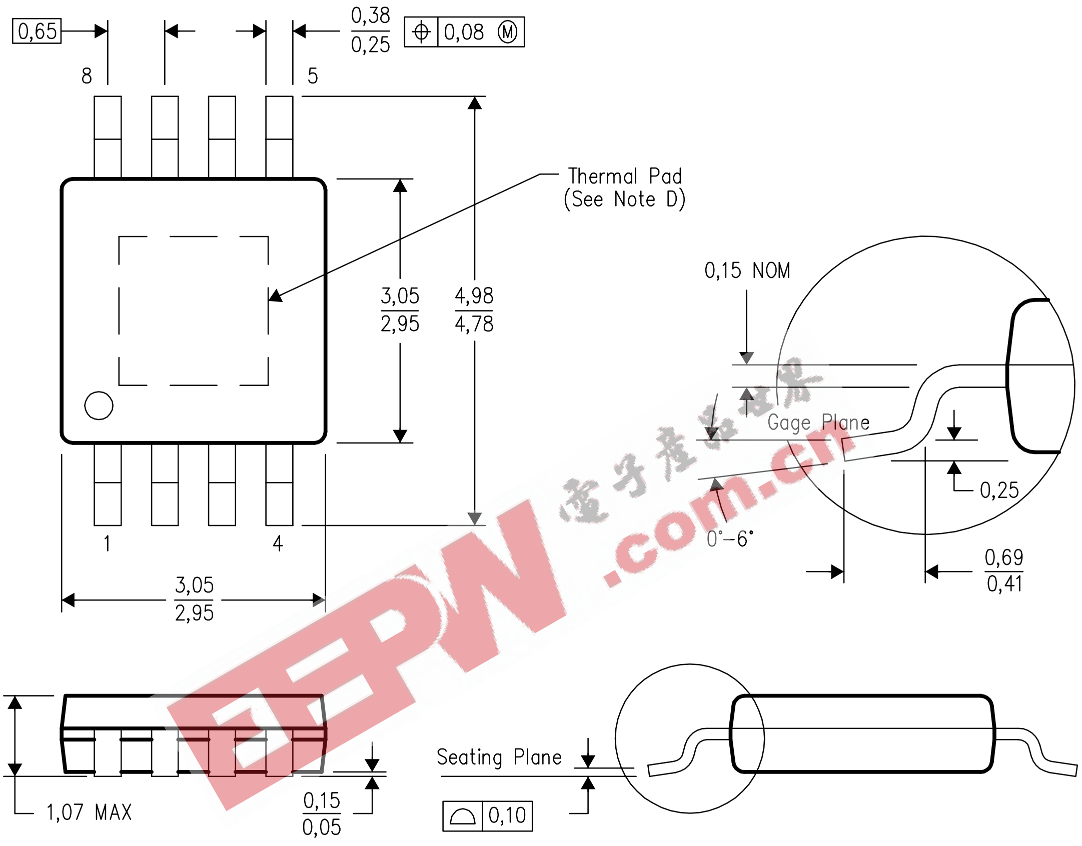


Figure 5. Maximum Power Dissipation vs Ambient Temperature

DGN (S-PDSO-G8) PowerPAD™ PLASTIC SMALL-OUTLINE PACKAGE



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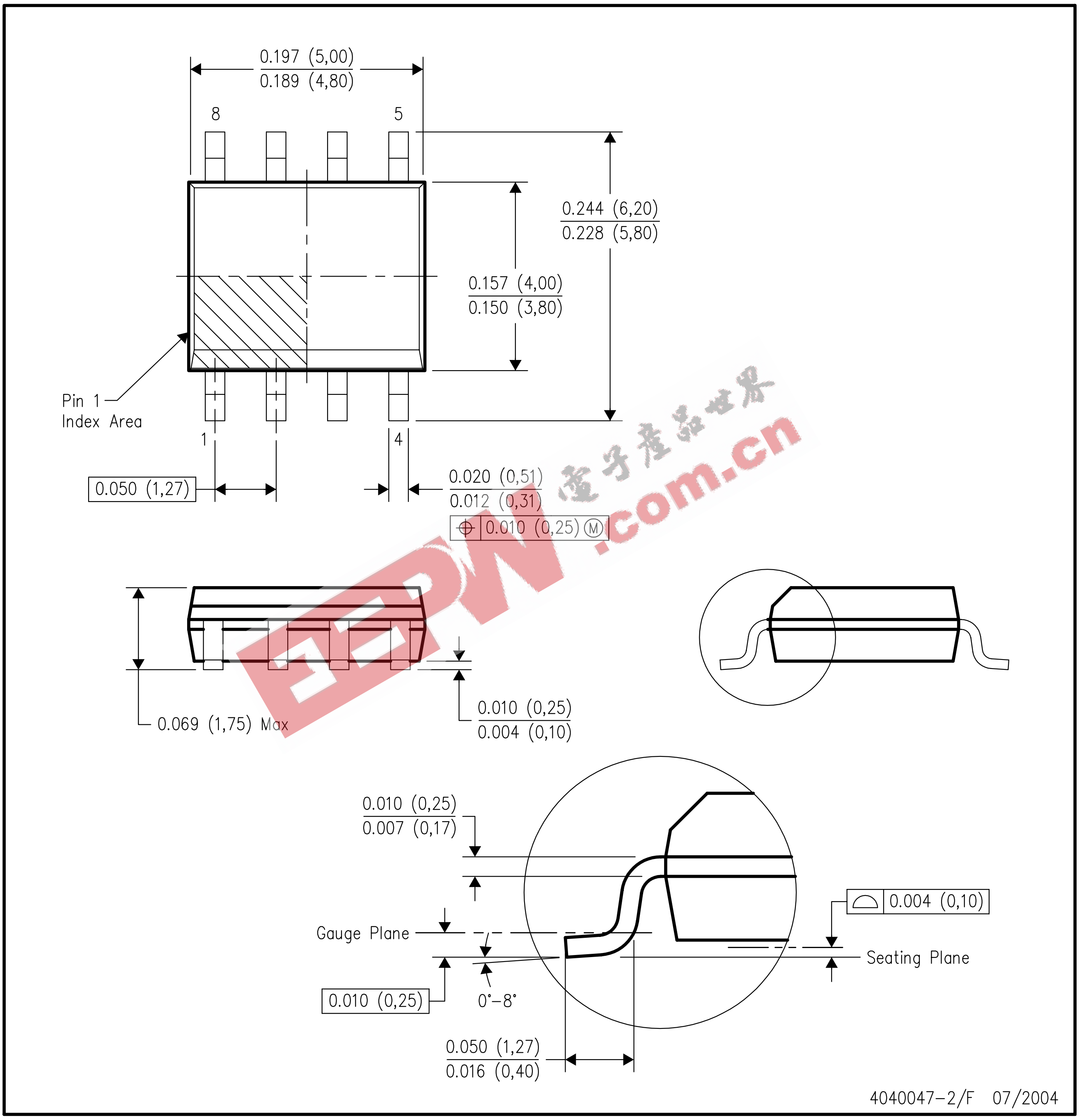
NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion.
- D. This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at www.ti.com <http://www.ti.com>.
- E. Falls within JEDEC MO-187

PowerPAD is a trademark of Texas Instruments.

D (R–PDSO–G8) PLASTIC SMALL–OUTLINE PACKAGE



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
- D. Falls within JEDEC MS–012 variation AA.

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