National Semiconductor

June 2005

LM4926 Boomer® Audio Power Amplifier Series
Ground-Referenced, Ultra Low Noise, Fixed Gain, 80mW Stereo Headphone Amplifier

General Description

The LM4926 is a ground referenced, fixed-gain audio power amplifier capable of delivering 80mW of continuous average power into a 16Ω single-ended load with less than 1% THD+N from a 3V power supply.

The LM4926 features a new circuit technology that utilizes a charge pump to generate a negative reference voltage. This allows the outputs to be biased about ground, thereby eliminating output-coupling capacitors typically used with normal single-ended loads.

The LM4926 features an Automatic Standby Mode circuitry (patent pending). In the absence of an input signal, after approximately 12 seconds, the LM4926 goes into low current standby mode. The LM4926 recovers into full power operating mode immediately after a signal is applied to either the left or right input pins. This feature saves power supply current in battery operated applications.

Boomer audio power amplifiers were designed specifically to provide high quality output power with a minimal amount of external components. The LM4926 does not require output coupling capacitors or bootstrap capacitors, and therefore is ideally suited for mobile phone and other low voltage applications where minimal power consumption is a primary requirement.

The LM4926 features a low-power consumption shutdown mode selectable for either channel separately. This is accomplished by driving either the SD_RC (Shutdown Right Channel) or SD_LC (Shutdown Left Channel) (or both) pins with logic low, depending on which channel is desired shutdown. Additionally, the LM4926 features an internal thermal shutdown protection mechanism.

The LM4926 contains advanced pop & click circuitry that eliminates noises which would otherwise occur during turn-on and turn-off transitions.

The LM4926 has an internal fixed gain of 1.5V/V.

Key Specifications

- Improved PSRR at 217Hz — 70dB (typ)
- Power Output at V_{DD} = 3V, R_L = 16Ω, THD ≦ 1% — 80mW (typ)
- Shutdown Current — 0.01µA (typ)
- Internal Fixed Gain — 1.5V/V (typ)
- Operating Voltage — 1.6V to 4.2V

Features

- Ground referenced outputs
- High PSRR
- Available in space-saving micro SMD package
- Ultra low current shutdown mode
- Improved pop & click circuitry eliminates noises during turn-on and turn-off transitions
- No output coupling capacitors, snubber networks, bootstrap capacitors, or gain-setting resistors required
- Shutdown either channel independently

Applications

- Notebook PCs
- Mobile Phone
- PDAs
- Portable electronic devices
- MP3 Players

Boomer® is a registered trademark of National Semiconductor Corporation.

Typical Application

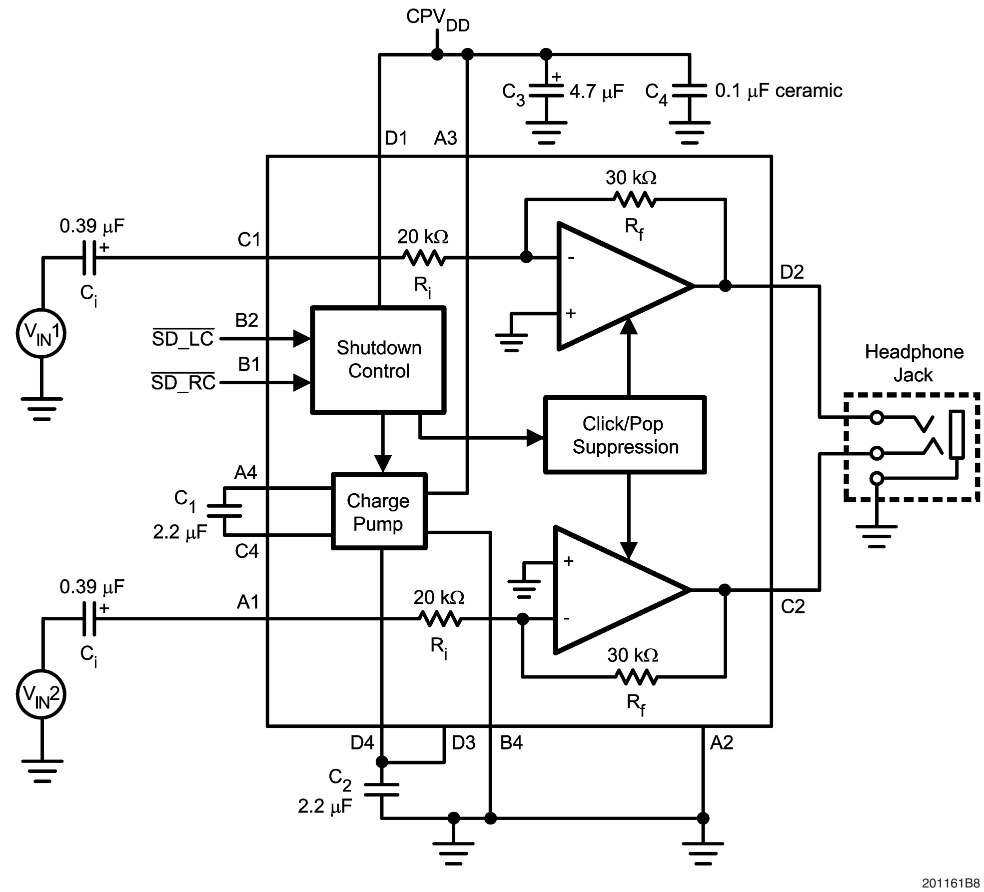
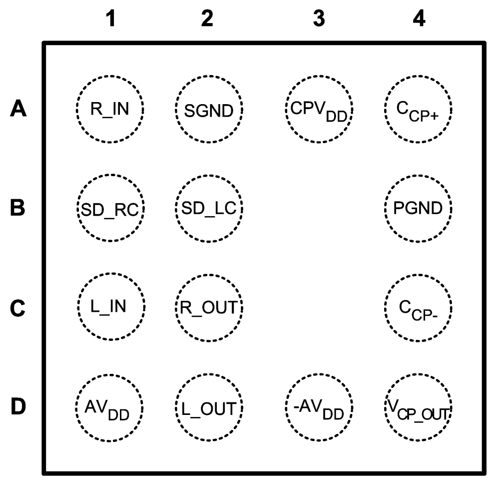


FIGURE 1. Typical Audio Amplifier Application Circuit

Connection Diagrams

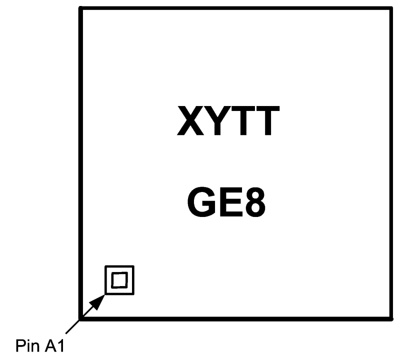
microSMD Package



20116109

Top View
Order Number LM4926TL
See NS Package Number TLE1411A

16 – Bump TL Marking



20116178

Top View
XY – Date Code
TT – Lot Traceability
G – Boomer Family
E8 – LM4926TL

Pin Descriptions

Pin	Name	Function
A1	R_IN	Right Channel Input
A2	SGND	Signal Ground
A3	CPV_{DD}	Charge Pump Power Supply
A4	C_{CP+}	Positive Terminal - Charge Pump Flying Capacitor
B1	SD_RC	Active-Low Shutdown, Right Channel
B2	SD_LC	Active-Low Shutdown, Left Channel
B4	PGND	Power Ground
C1	L_IN	Left Channel Input
C2	R_OUT	Right Channel Input
C4	C_{CP-}	Negative Terminal - Charge Pump Flying Capacitor
D1	$+AV_{DD}$	Positive Power Supply - Amplifier
D2	L_OUT	Left Channel Output
D3	$-AV_{DD}$	Negative Power Supply - Amplifier
D4	V_{CP_OUT}	Charge Pump Power Output

Absolute Maximum Ratings (Note 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage	4.5V
Storage Temperature	–65˚C to +150˚C
Input Voltage	-0.3V to V_{DD} + 0.3V
Power Dissipation (Note 3)	Internally Limited
ESD Susceptibility (Note 4)	2000V
ESD Susceptibility (Note 5)	200V
Junction Temperature	150˚C
Thermal Resistance	
θ_{JA} (typ) TLE1411A (Note 11)	86˚C/W

Operating Ratings

Temperature Range	
$T_{MIN} \leq T_A \leq T_{MAX}$	$-40˚C \leq T_A \leq 85˚C$
Supply Voltage (V_{DD})	$1.6V \leq V_{DD} \leq 4.2V$

Electrical Characteristics V_{DD} = 3V (Note 1)

The following specifications apply for V_{DD} = 3V and 16Ω load unless otherwise specified. Limits apply to T_A = 25˚C.

Symbol	Parameter	Conditions	LM4926 Typ (Note 6)	LM4926 Limit (Notes 7, 8)	Units (Limits)
I_{DD}	Quiescent Power Supply Current Auto Standby Mode	V_{IN} = 0V, inputs terminated both channels enabled	2.3		mA
	Quiescent Power Supply Current Full Power Mode	V_{IN} = 0V, inputs terminated both channels enabled	7	10	mA (max)
		V_{IN} = 0V, inputs terminated one channel enabled	5		mA
I_{SD}	Shutdown Current	$V_{SD\_LC} = V_{SD\_RC}$ = GND	0.1	1.8	µA (max)
V_{OS}	Output Offset Voltage	R_L = 32Ω, V_{IN} = 0V	0.7	5	mV (max)
A_V	Voltage Gain		–1.5		V/V
ΔA_V	Gain Match		1		%
R_{IN}	Input Resistance		20	15 25	kΩ (min) kΩ (max)
P_O	Output Power	THD+N = 1% (max); f = 1kHz, R_L = 16Ω, one channel	80		mW
		THD+N = 1% (max); f = 1kHz, R_L = 32Ω, one channel	65		mW
		THD+N = 1% (max); f = 1kHz, R_L = 16Ω, (two channels in phase)	43	38	mW (min)
		THD+N = 1% (max); f = 1kHz, R_L = 32Ω, (two channels in phase)	50	45	mW (min)
THD+N	Total Harmonic Distortion + Noise	P_O = 60mW, f = 1kHz, R_L = 16Ω single channel	0.04		%
		P_O = 50mW, f = 1kHz, R_L = 32Ω single channel	0.03		
PSRR	Power Supply Rejection Ratio Full Power Mode	V_{RIPPLE} = 200mVp-p, Input Referred			
		f = 217Hz	70		dB
		f = 1kHz	65		
		f = 20kHz	50		
SNR	Signal-to-Noise Ratio	R_L = 32Ω, P_{OUT} = 20mW, (A-weighted) f = 1kHz, BW = 20Hz to 22kHz	100		dB
V_{IH}	Shutdown Input Voltage High		V_{IH} = 0.7*CPV_{DD}		V
V_{IL}	Shutdown Input Voltage Low		V_{IL} = 0.3*CPV_{DD}		V
T_{WU}	Wake Up Time From Shutdown		5		µs

Electrical Characteristics V_{DD} = 3V (Note 1) (Continued)

The following specifications apply for V_{DD} = 3V and 16Ω load unless otherwise specified. Limits apply to T_A = 25˚C.

Symbol	Parameter	Conditions	LM4926		Units (Limits)
			Typ (Note 6)	Limit (Notes 7, 8)	
X_{TALK}	Crosstalk	R_L = 16Ω, P_O = 1.6mW, f = 1kHz	60		dB
Z_{OUT}	Output Impedance	Input Terminated Input not terminated	∞ 60		kΩ
I_L	Input Leakage		±0.1		nA
$V_{IN\ THRESH}$	Input Voltage Threshold		2.8		mVp

Note 1: All voltages are measured with respect to the GND pin unless otherwise specified.

Note 2: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional but do not guarantee specific performance limits. Electrical Characteristics state DC and AC electrical specifications under particular test conditions that guarantee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters where no limit is given; however, the typical value is a good indication of device performance.

Note 3: The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{JMAX}, θ_{JA}, and the ambient temperature, T_A. The maximum allowable power dissipation is $P_{DMAX} = (T_{JMAX} - T_A) / \theta_{JA}$ or the number given in Absolute Maximum Ratings, whichever is lower. For the LM4926, see power de-rating currents for more information.

Note 4: Human body model, 100pF discharged through a 1.5kΩ resistor.

Note 5: Machine Model, 220pF - 240pF discharged through all pins.

Note 6: Typicals are measured at 25˚C and represent the parametric norm.

Note 7: Limits are guaranteed to National's AOQL (Average Outgoing Quality Level).

Note 8: Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

Note 9: If the product is in shutdown mode and V_{DD} exceeds 4.2V (to a max of 4.5V V_{DD}), then most of the excess current will flow through the ESD protection circuits. If the source impedance limits the current to a max of 10mA, then the part will be protected. If the part is enabled when V_{DD} is above 4.5V, circuit performance will be curtailed or the part may be permanently damaged.

Note 10: Human body model, 100pF discharged through a 1.5kΩ resistor.

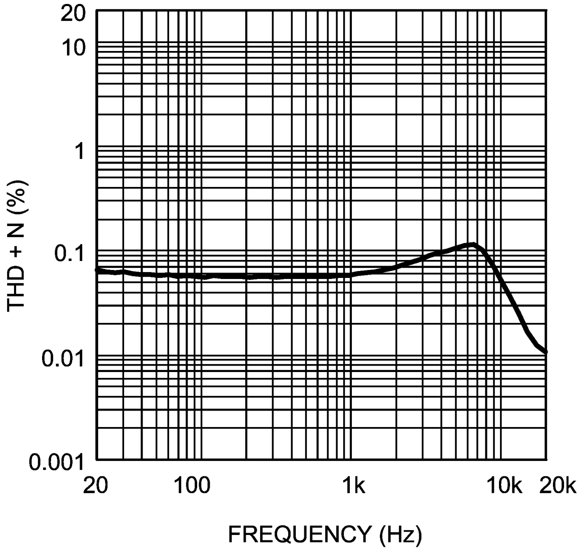
Note 11: θ_{JA} value is measured with the device mounted on a PCB with a 3" x 1.5", 1oz copper heatsink.

External Components Description (*Figure 1*)

Components		Functional Description
1.	C_i	Input coupling capacitor which blocks the DC voltage at the amplifier's input terminals. Also creates a high-pass filter with R_i at $f_C = 1/(2\pi R_i C_i)$. Refer to the section **Proper Selection of External Components,** for an explanation of how to determine the value of C_i.
2.	C_1	Flying capacitor. Low ESR ceramic capacitor (≤100mΩ)
3.	C_2	Output capacitor. Low ESR ceramic capacitor (≤100mΩ)
4.	C_3	Tantalum capacitor. Supply bypass capacitor which provides power supply filtering. Refer to the Power Supply Bypassing section for information concerning proper placement and selection of the supply bypass capacitor.
5.	C_4	Ceramic capacitor. Supply bypass capacitor which provides power supply filtering. Refer to the Power Supply Bypassing section for information concerning proper placement and selection of the supply bypass capacitor.

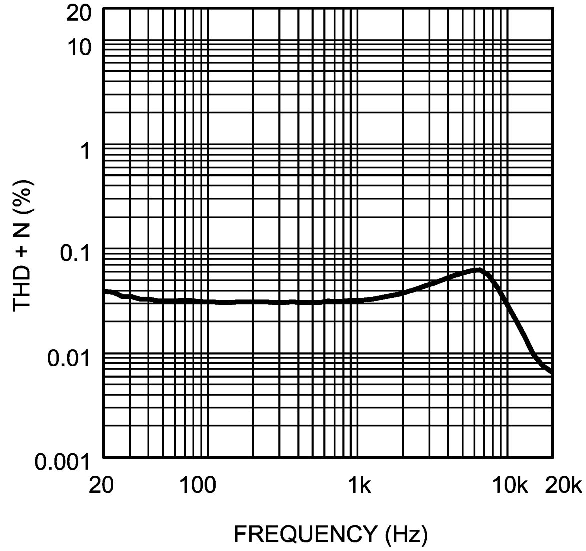
Typical Performance Characteristics

THD+N vs Frequency
V_{DD} = 1.6V, R_L = 16Ω, P_O = 1mW



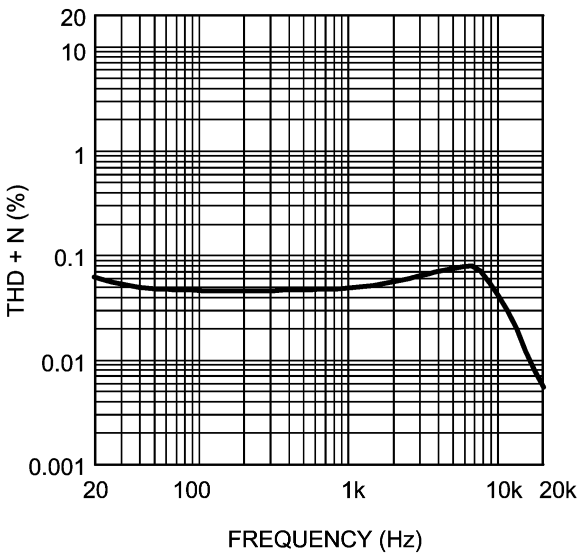
20116128

THD+N vs Frequency
V_{DD} = 1.6V, R_L = 32Ω, P_O = 1mW



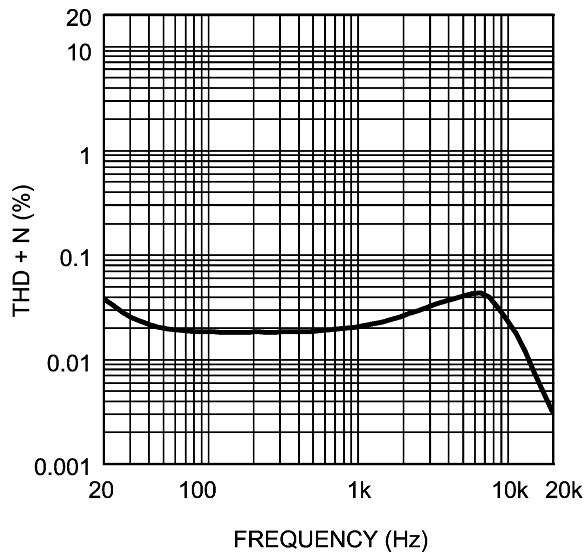
20116129

THD+N vs Frequency
V_{DD} = 1.8V, R_L = 16Ω, P_O = 5mW



20116130

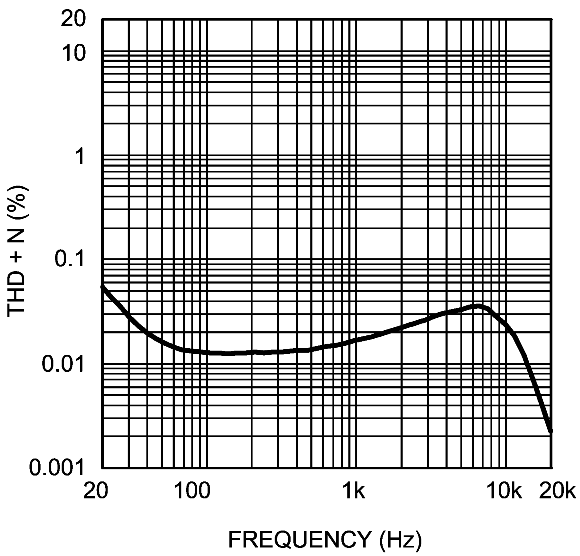
THD+N vs Frequency
V_{DD} = 1.8V, R_L = 32Ω, P_O = 5mW



20116131

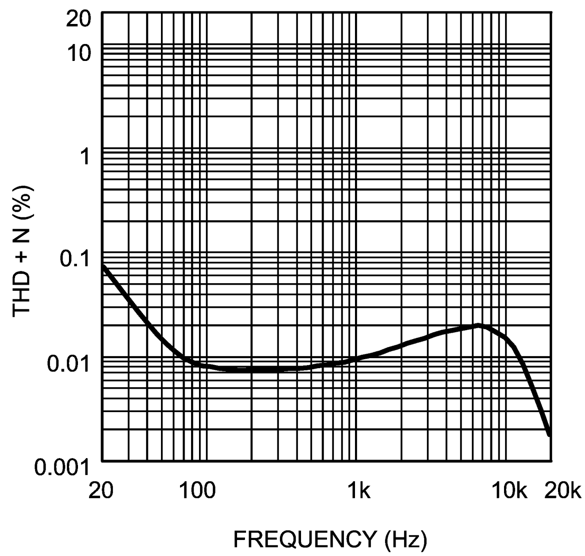
Typical Performance Characteristics (Continued)

THD+N vs Frequency
V_{DD} = 3V, R_L = 16Ω, P_O = 50mW



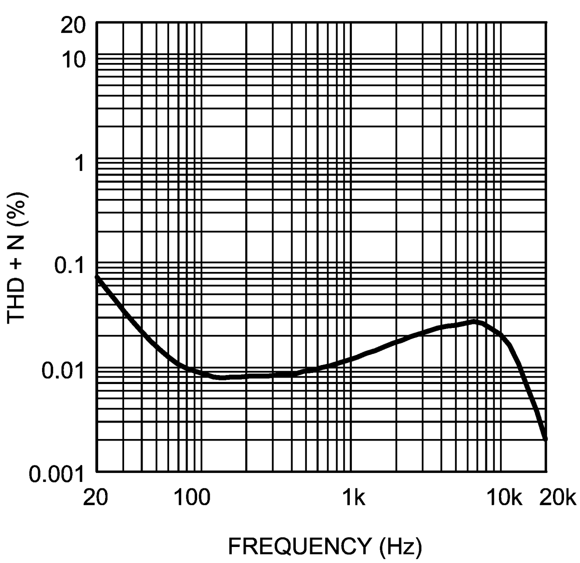
20116132

THD+N vs Frequency
V_{DD} = 3V, R_L = 32Ω, P_O = 50mW



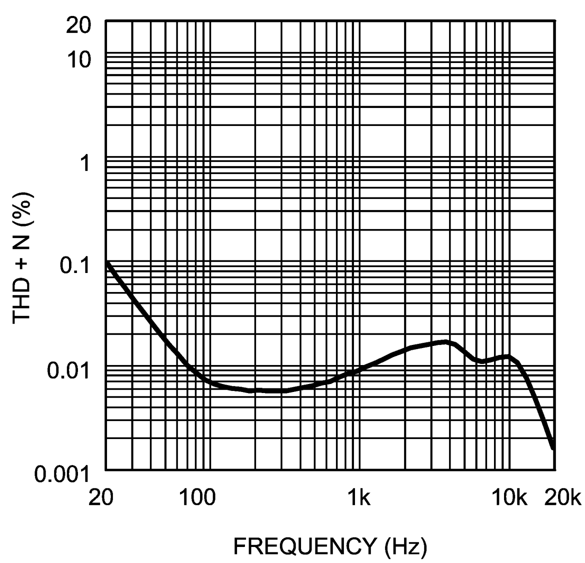
20116133

THD+N vs Frequency
V_{DD} = 3.6V, R_L = 16Ω, P_O = 100mW



20116134

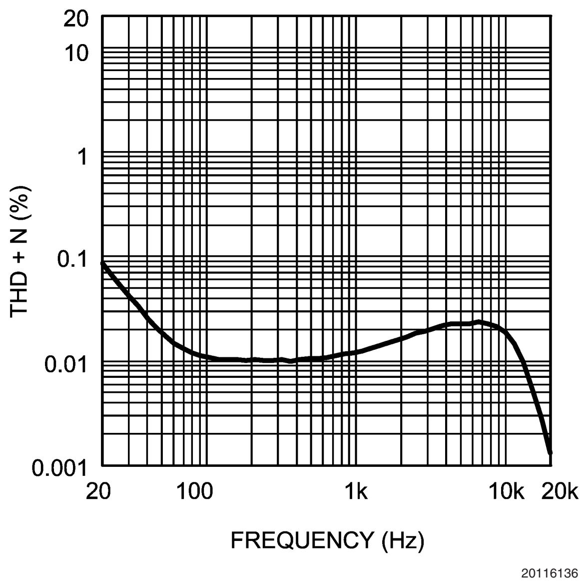
THD+N vs Frequency
V_{DD} = 3.6V, R_L = 32Ω, P_O = 100mW



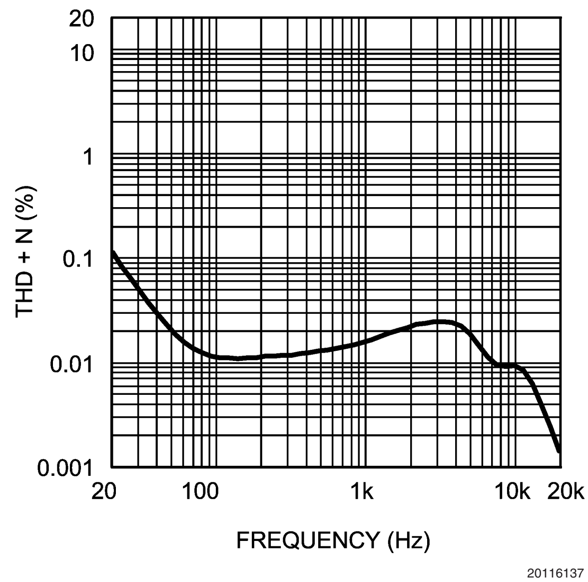
20116135

Typical Performance Characteristics (Continued)

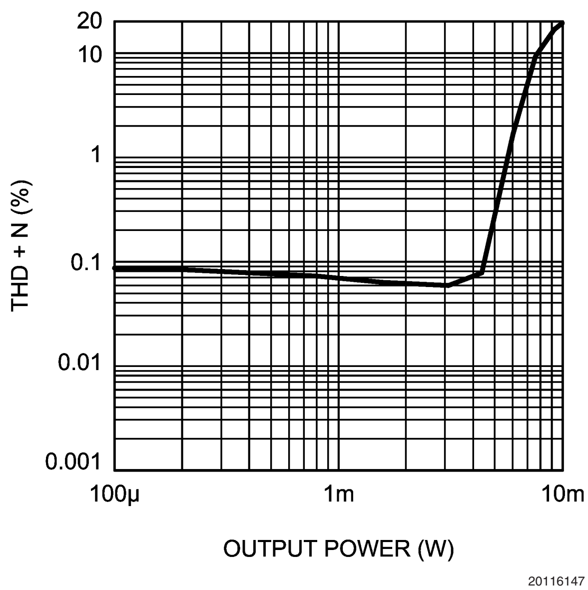
THD+N vs Frequency
V_{DD} = 4.2V, R_L = 16Ω, P_O = 150mW



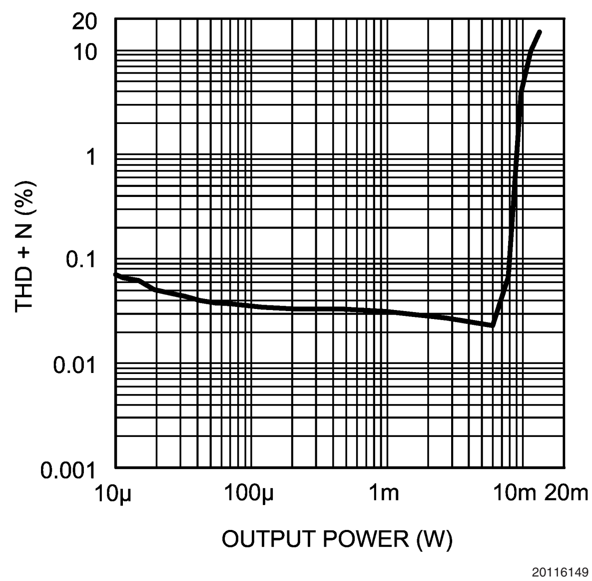
THD+N vs Frequency
V_{DD} = 4.2V, R_L = 32Ω, P_O = 150mW



THD+N vs Output Power
V_{DD} = 1.6V, R_L = 16Ω, f = 1kH
One channel enabled

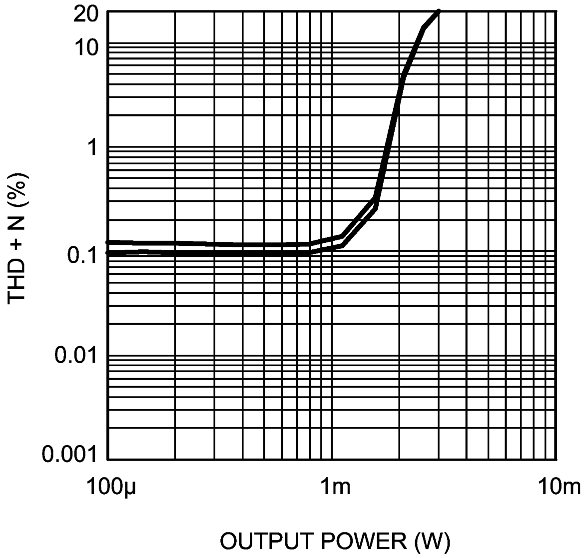


THD+N vs Output Power
V_{DD} = 1.6V, R_L = 32Ω, f = 1kHz
One channel enabled



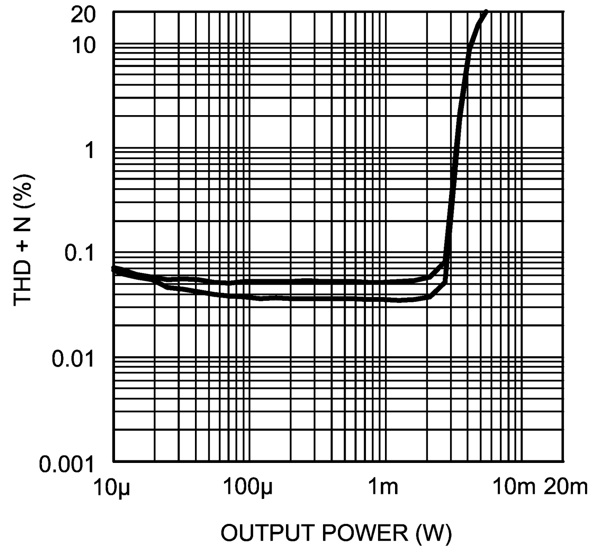
Typical Performance Characteristics (Continued)

THD+N vs Output Power
V_{DD} = 1.6V, R_L = 16Ω, f = 1kHz
Two channels in phase



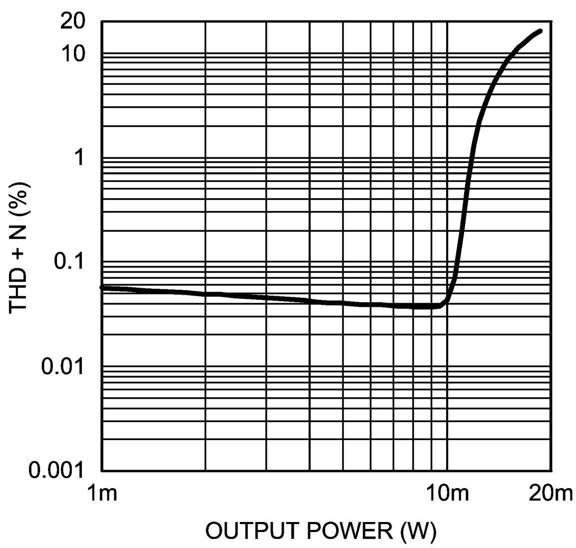
20116151

THD+N vs Output Power
V_{DD} = 1.6V, R_L = 32Ω, f = 1kHz
Two channels in phase



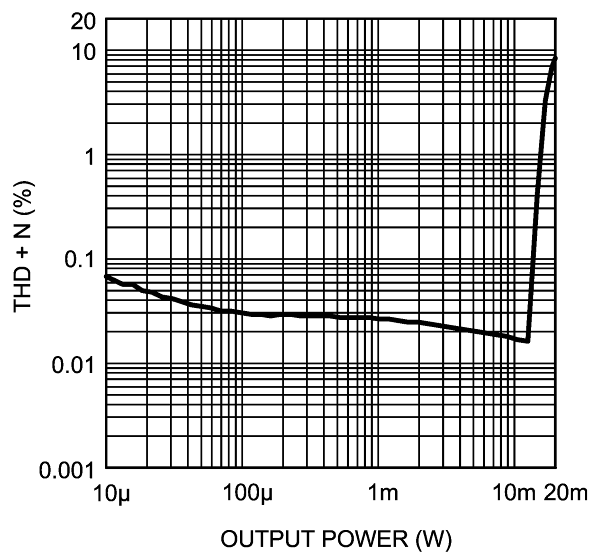
20116153

THD+N vs Output Power
V_{DD} = 1.8V, R_L = 16Ω, f = 1kHz
One channel enabled



20116159

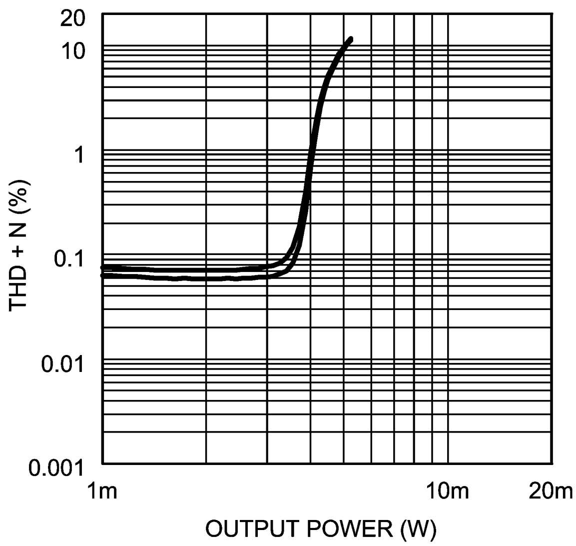
THD+N vs Output Power
V_{DD} = 1.8V, R_L = 32Ω, f = 1kHz
One channel enabled



20116161

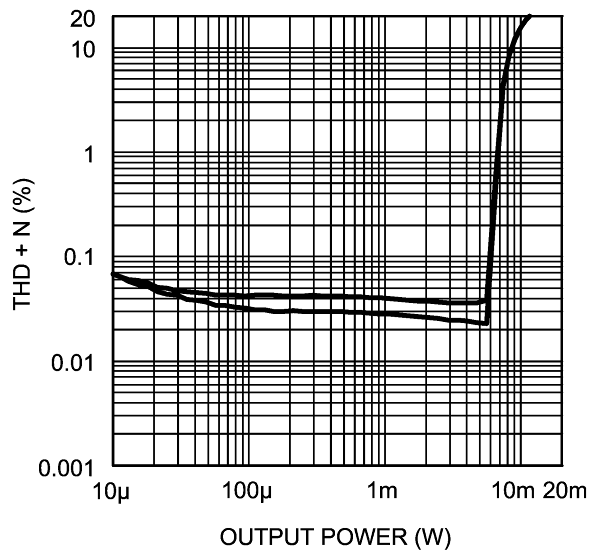
Typical Performance Characteristics (Continued)

THD+N vs Output Power
V_{DD} = 1.8V, R_L = 16Ω, f = 1kHz
Two channels in phase



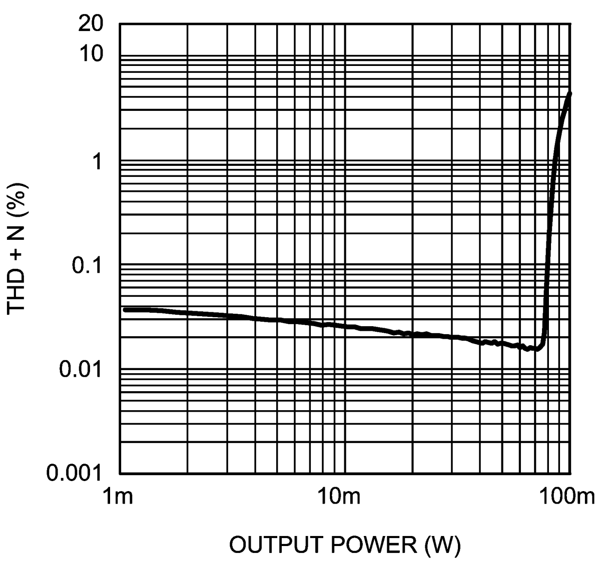
20116163

THD+N vs Output Power
V_{DD} = 1.8V, R_L = 32Ω, f = 1kHz
Two channels in phase



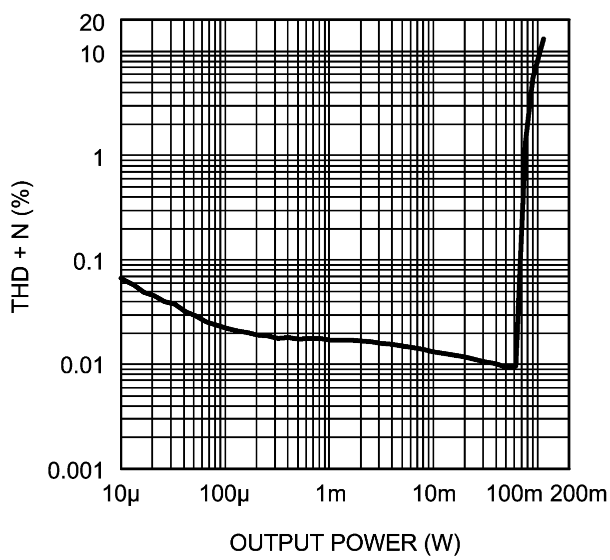
20116165

THD+N vs Output Power
V_{DD} = 3.0V, R_L = 16Ω, f = 1kHz
One channel enabled



201161G2

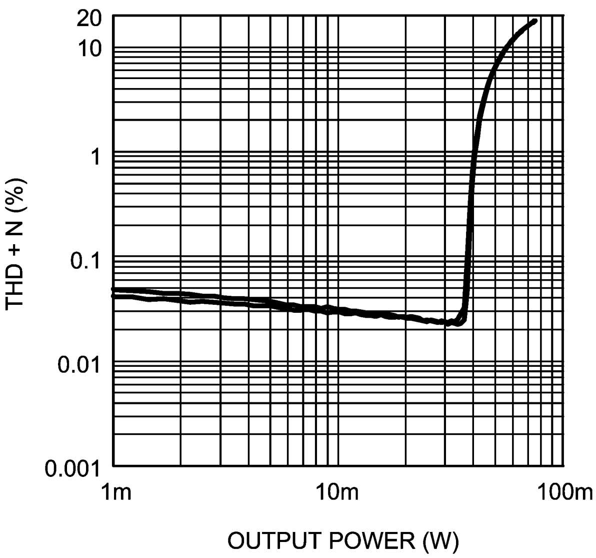
THD+N vs Output Power
V_{DD} = 3.0V, R_L = 32Ω, f = 1kHz
One channel enabled



201161E1

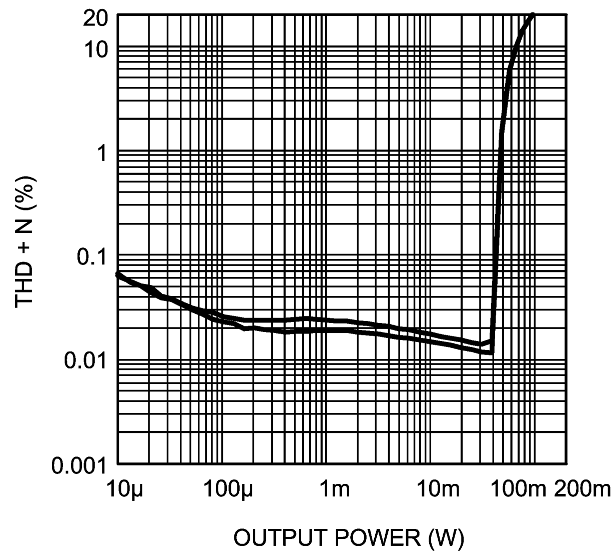
Typical Performance Characteristics (Continued)

THD+N vs Output Power
V_{DD} = 3.0V, R_L = 16Ω, f = 1kHz
Two channels in phase



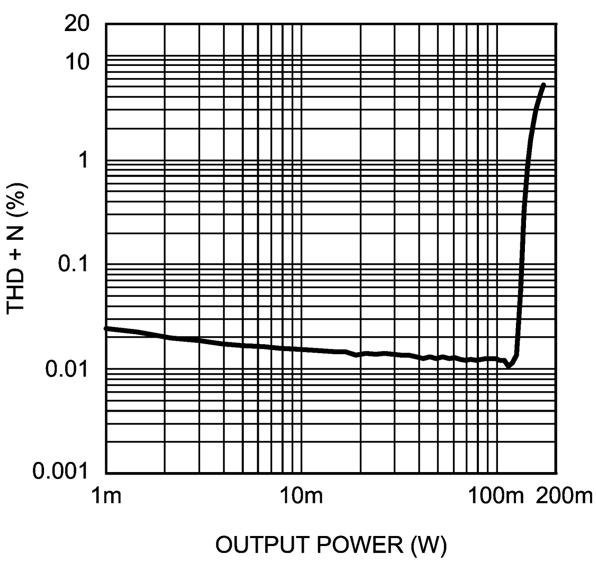
201161G4

THD+N vs Output Power
V_{DD} = 3.0V, R_L = 32Ω, f = 1kHz
Two channels in phase



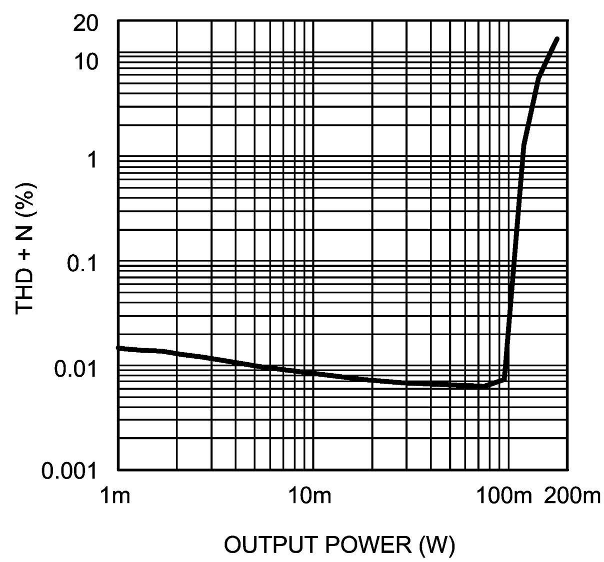
201161E5

THD+N vs Output Power
V_{DD} = 3.6V, R_L = 16Ω, f = 1kHz
One channel enabled



201161F1

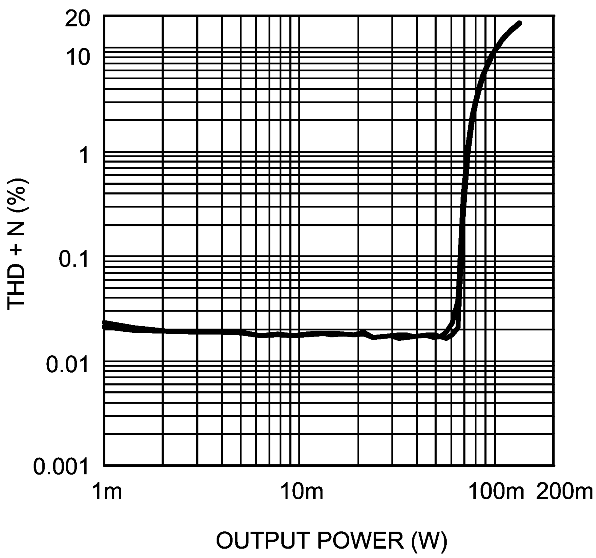
THD+N vs Output Power
V_{DD} = 3.6V, R_L = 32Ω, f = 1kHz
One channel enabled



201161F3

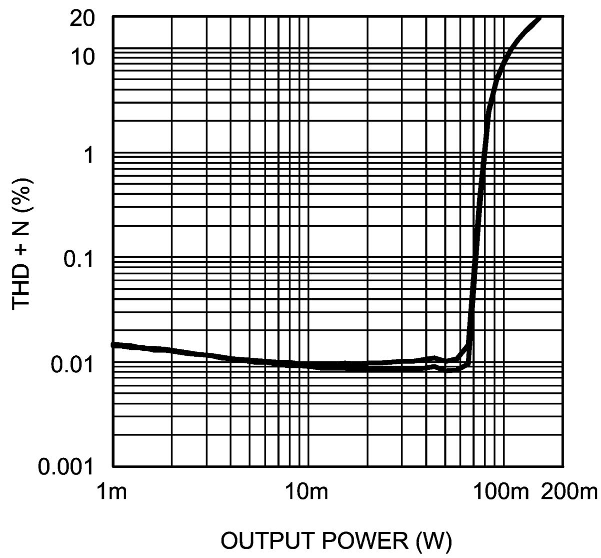
Typical Performance Characteristics (Continued)

THD+N vs Output Power
V_{DD} = 3.6V, R_L = 16Ω, f = 1kHz
Two channels in phase



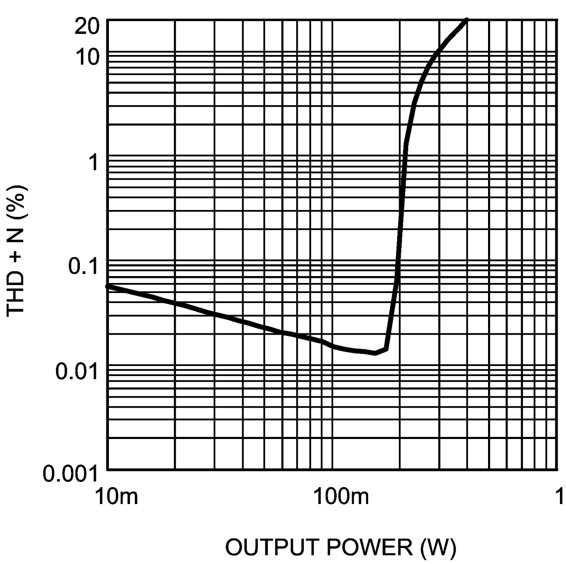
201161F5

THD+N vs Output Power
V_{DD} = 3.6V, R_L = 32Ω, f = 1kHz
two channels in phase



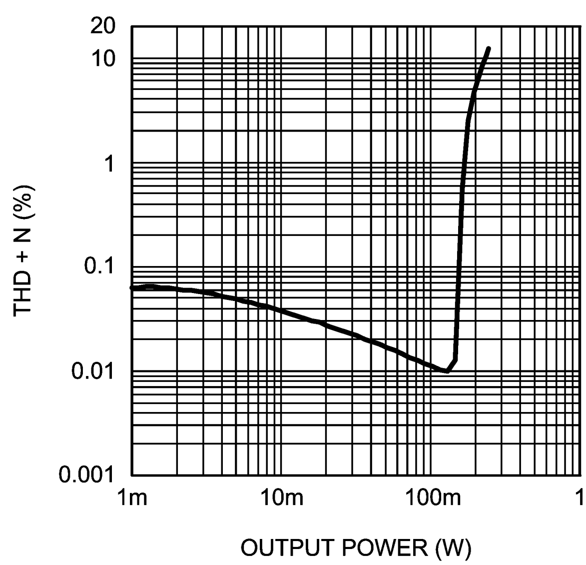
201161F7

THD+N vs Output Power
V_{DD} = 4.2V, R_L = 16Ω, f = 1kHz
One channel enabled



20116173

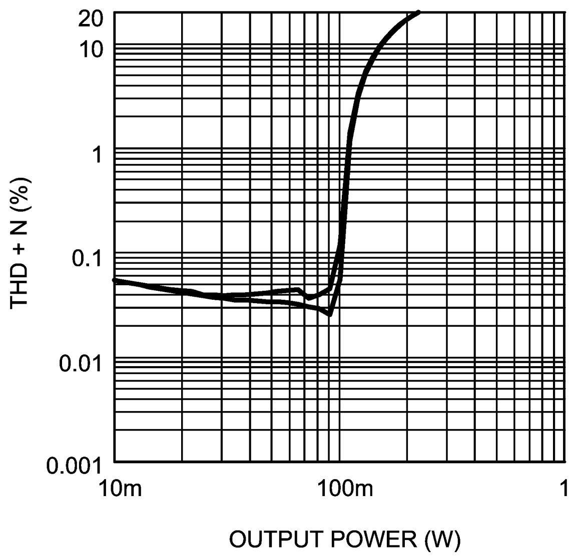
THD+N vs Output Power
V_{DD} = 4.2V, R_L = 32Ω, f = 1kHz
One channel enabled



20116180

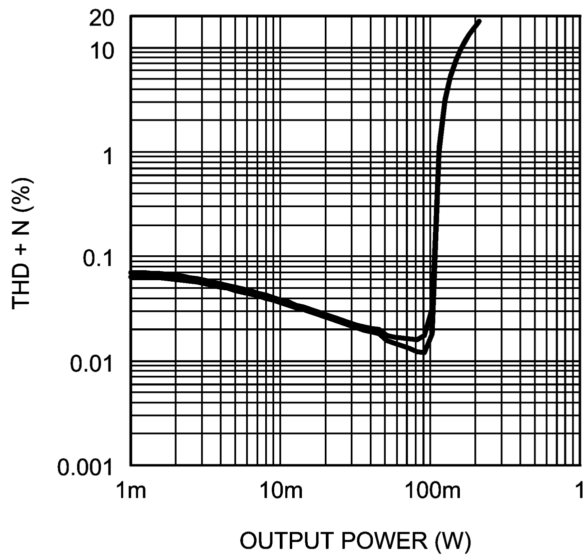
Typical Performance Characteristics (Continued)

THD+N vs Output Power
V_{DD} = 4.2V, R_L = 16Ω, f = 1kHz
Two channels in phase



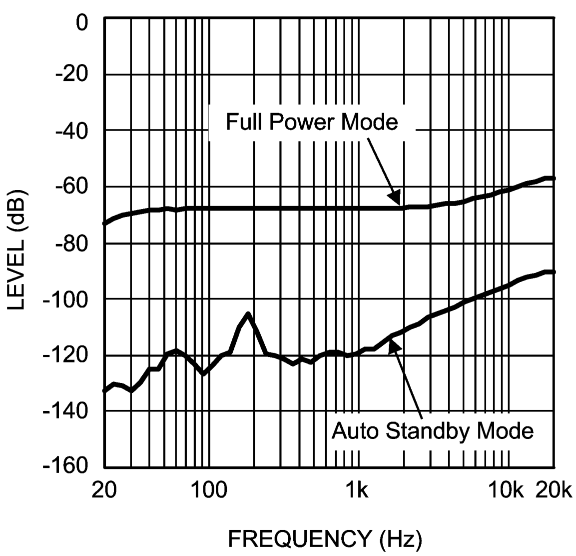
20116182

THD+N vs Output Power
V_{DD} = 4.2V, R_L = 32Ω, f = 1kHz
Two channels in phase



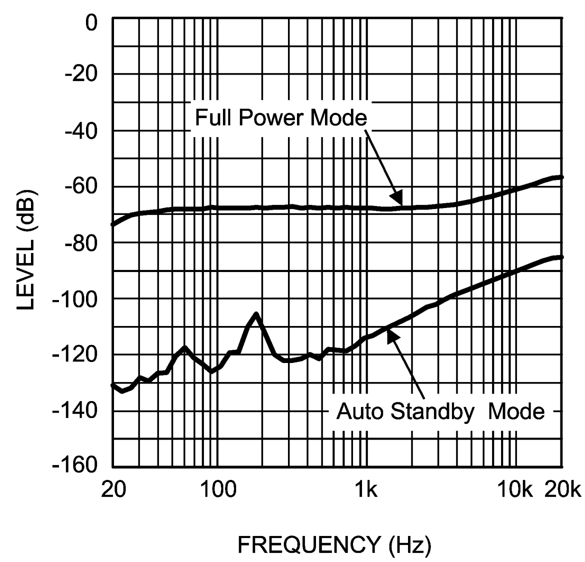
20116184

PSRR vs Frequency
V_{DD} = 1.6V, R_L = 16Ω



20116140

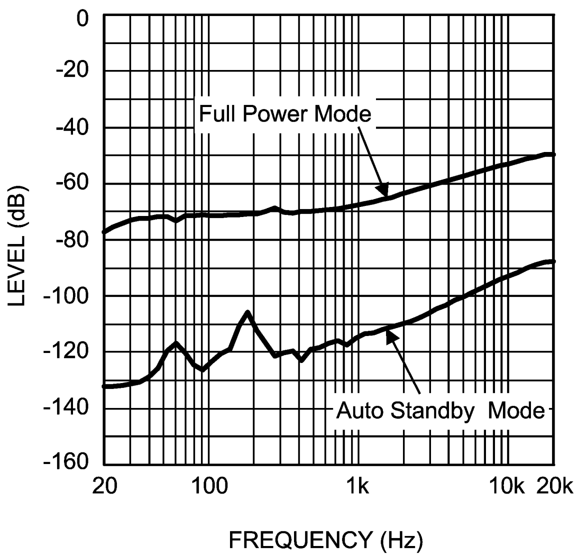
PSRR vs Frequency
V_{DD} = 1.6V, R_L = 32Ω



20116141

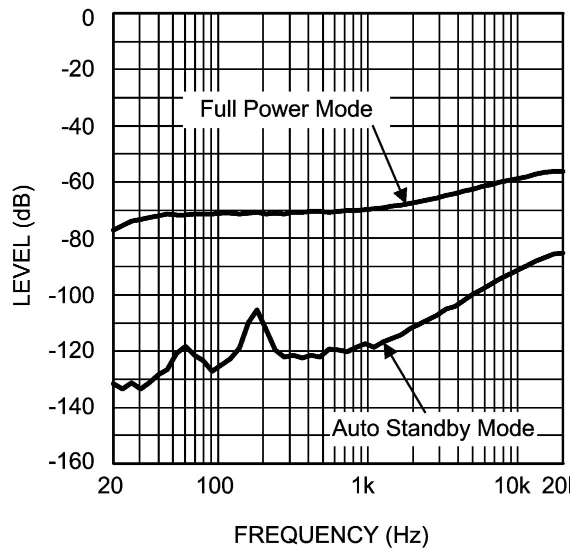
Typical Performance Characteristics (Continued)

PSRR vs Frequency
V_{DD} = 3V, R_L = 16Ω



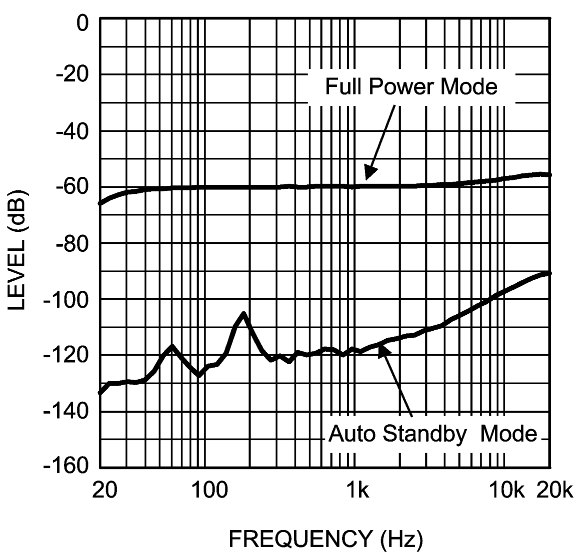
20116142

PSRR vs Frequency
V_{DD} = 3V, R_L = 32Ω



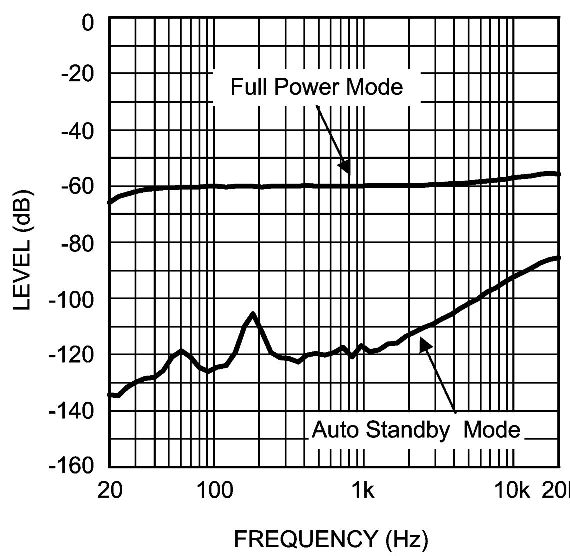
20116143

PSRR vs Frequency
V_{DD} = 4.2V, R_L = 16Ω



20116144

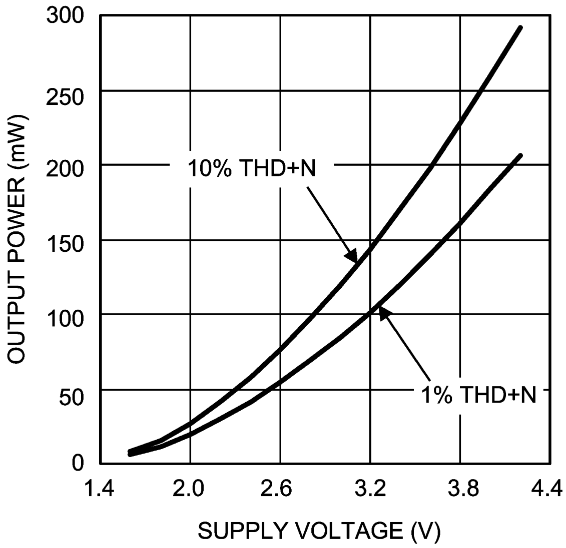
PSRR vs Frequency
V_{DD} = 4.2V, R_L = 32Ω



20116145

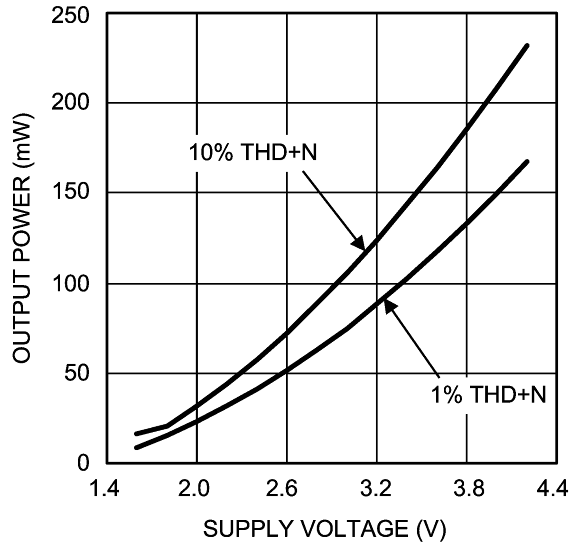
Typical Performance Characteristics (Continued)

Output Power vs Supply Voltage
R_L = 16Ω, one channel



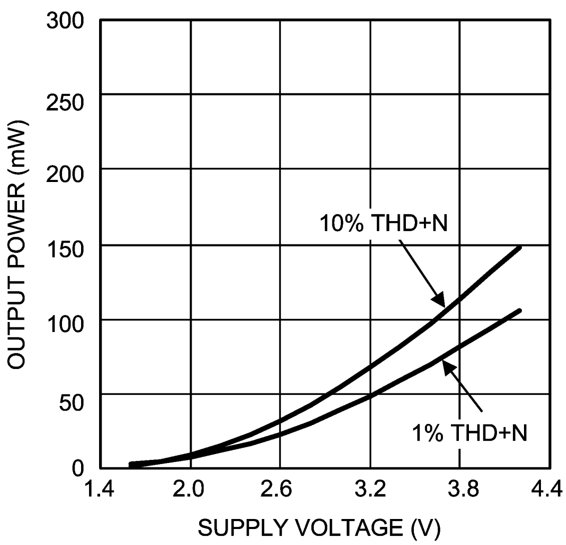
20116138

Output Power vs Supply Voltage
R_L = 32Ω, one channel



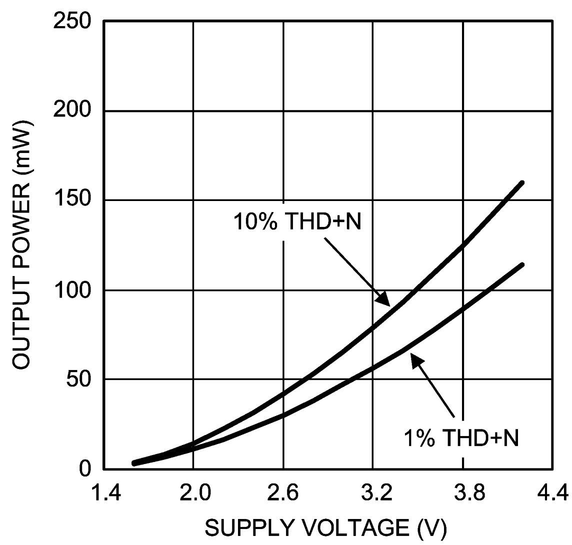
20116139

Output Power vs Supply Voltage
R_L = 16Ω, 2 channels in phase



201161G8

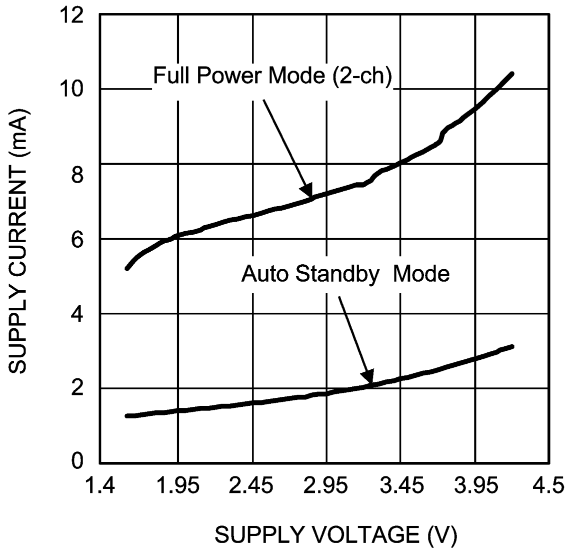
Output Power vs Supply Voltage
R_L = 32Ω, 2 channels in phase



201161G9

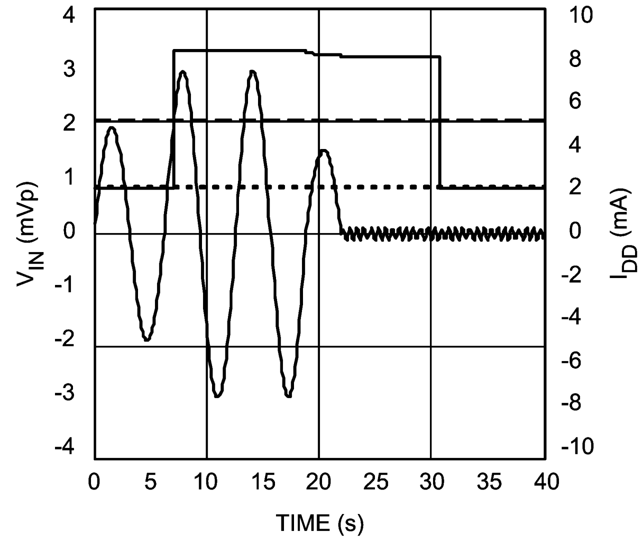
Typical Performance Characteristics (Continued)

Supply Current vs Supply Voltage
R_L = 16Ω



20116189

Representation of Automatic Standby Mode Behavior
V_{DD} = 3V



20116119

Application Information

SUPPLY VOLTAGE SEQUENCING

It is a good general practice to first apply the supply voltage to a CMOS device before any other signal or supply on other pins. This is also true for the LM4926 audio amplifier which is a CMOS device.

Before applying any signal to the inputs or shutdown pins of the LM4926, it is important to apply a supply voltage to the V_{DD} pins. After the device has been powered, signals may be applied to the shutdown pins (see MICRO POWER SHUTDOWN) and input pins.

ELIMINATING THE OUTPUT COUPLING CAPACITOR

The LM4926 features a low noise inverting charge pump that generates an internal negative supply voltage. This allows the outputs of the LM4926 to be biased about GND instead of a nominal DC voltage, like traditional headphone amplifiers. Because there is no DC component, the large DC blocking capacitors (typically 220µF) are not necessary. The coupling capacitors are replaced by two, small ceramic charge pump capacitors, saving board space and cost.

Eliminating the output coupling capacitors also improves low frequency response. In traditional headphone amplifiers, the headphone impedance and the output capacitor form a high pass filter that not only blocks the DC component of the output, but also attenuates low frequencies, impacting the bass response. Because the LM4926 does not require the output coupling capacitors, the low frequency response of the device is not degraded by external components.

In addition to eliminating the output coupling capacitors, the ground referenced output nearly doubles the available dynamic range of the LM4926 when compared to a traditional headphone amplifier operating from the same supply voltage.

OUTPUT TRANSIENT ('CLICK AND POPS') ELIMINATED

The LM4926 contains advanced circuitry that virtually eliminates output transients ('clicks and pops'). This circuitry prevents all traces of transients when the supply voltage is first applied or when the part resumes operation after coming out of shutdown mode.

AMPLIFIER CONFIGURATION EXPLANATION

As shown in Figure 2, the LM4926 has two internal operational amplifiers. The two amplifiers have internally configured gain, the closed loop gain is set by selecting the ratio of R_f to R_i. Consequently, the gain for each channel of the IC is

$$A_V = -(R_f / R_i) = 1.5\ V/V$$

where $R_F = 30k\Omega$ and $R_i = 20k\Omega$.

Since this is an output ground-referenced amplifier, by driving the headphone through R_{OUT} (Pin C2) and L_{OUT} (Pin D2), the LM4926 does not require output coupling capacitors. The typical single-ended amplifier configuration requires large, expensive output capacitors.

POWER DISSIPATION

Power dissipation is a major concern when using any power amplifier and must be thoroughly understood to ensure a successful design. Equation 1 states the maximum power dissipation point for a single-ended amplifier operating at a given supply voltage and driving a specified output load.

$$P_{DMAX} = (V_{DD})^2 / (2\pi^2 R_L) \quad (1)$$

Since the LM4926 has two operational amplifiers in one package, the maximum internal power dissipation point is twice that of the number which results from Equation 1. Even with large internal power dissipation, the LM4926 does not require heat sinking over a large range of ambient temperatures. From Equation 1, assuming a 3V power supply and a 16Ω load, the maximum power dissipation point is 28mW per amplifier. Thus the maximum package dissipation point is 56mW. The maximum power dissipation point obtained must not be greater than the power dissipation that results from Equation 2:

$$P_{DMAX} = (T_{JMAX} - T_A) / (\theta_{JA}) \quad (2)$$

For the micro SMD package, $\theta_{JA} = 105°C/W$. $T_{JMAX} = 150°C$ for the LM4926. Depending on the ambient temperature, T_A, of the system surroundings, Equation 2 can be used to find the maximum internal power dissipation supported by the IC packaging. If the result of Equation 1 is greater than that of Equation 2, then either the supply voltage must be decreased, the load impedance increased or T_A reduced. For the typical application of a 3V power supply, with a 16Ω load, the maximum ambient temperature possible without violating the maximum junction temperature is approximately 144°C provided that device operation is around the maximum power dissipation point. Power dissipation is a function of output power and thus, if typical operation is not around the maximum power dissipation point, the ambient temperature may be increased accordingly.

POWER SUPPLY BYPASSING

As with any power amplifier, proper supply bypassing is critical for low noise performance and high power supply rejection. Applications that employ a 3V power supply typically use a 4.7µF capacitor in parallel with a 0.1µF ceramic filter capacitor to stabilize the power supply's output, reduce noise on the supply line, and improve the supply's transient response. Keep the length of leads and traces that connect capacitors between the LM4926's power supply pin and ground as short as possible.

AUTOMATIC STANDBY MODE

The LM4926 features Automatic Standby Mode circuitry (patent pending). In the absence of an input signal, after approximately 12 seconds, the LM4926 goes into low current standby mode. The LM4926 recovers into full power operating mode immediately after a signal, which is greater than the input threshold voltage, is applied to either the left or right input pins. The input threshold voltage is not a static value, as the supply voltage increases, the input threshold voltage decreases. This feature reduces power supply current consumption in battery operated applications. Please see also the graph entitled Representation of Automatic Standby Mode Behavior in the Typical Performance Characteristics section.

Application Information (Continued)

To ensure correct operation of Automatic Standby Mode, proper layout techniques should be implemented. Separating PGND and SGND can help reduce noise entering the LM4926 in noisy environments. Auto Standby mode works best when output impedance of the audio source driving LM4926 is equal or less than 50 Ohms. While Automatic Standby Mode reduces power consumption very effectively during silent periods, maximum power saving is achieved by putting the device into shutdown when it is not in use.

MICRO POWER SHUTDOWN

The voltage applied to the $\overline{SD\_LC}$ (shutdown left channel) pin and the $\overline{SD\_RC}$ (shutdown right channel) pin controls the LM4926's shutdown function. When active, the LM4926's micropower shutdown feature turns off the amplifiers' bias circuitry, reducing the supply current. The trigger point is 0.3*CPV_{DD} for a logic-low level, and 0.7*CPV_{DD} for logic-high level. The low 0.01µA (typ) shutdown current is achieved by applying a voltage that is as near as ground a possible to the $\overline{SD\_LC}$/$\overline{SD\_RC}$ pins. A voltage that is higher than ground may increase the shutdown current.

There are a few ways to control the micro-power shutdown. These include using a single-pole, single-throw switch, a microprocessor, or a microcontroller. When using a switch, connect an external 100kΩ pull-up resistor between the $\overline{SD\_LC}$/$\overline{SD\_RC}$ pins and V_{DD}. Connect the switch between the $\overline{SD\_LC}$/$\overline{SD\_RC}$ pins and ground. Select normal amplifier operation by opening the switch. Closing the switch connects the $\overline{SD\_LC}$/$\overline{SD\_RC}$ pins to ground, activating micro-power shutdown. The switch and resistor guarantee that the $\overline{SD\_LC}$/$\overline{SD\_RC}$ pins will not float. This prevents unwanted state changes. In a system with a microprocessor or microcontroller, use a digital output to apply the control voltage to the $\overline{SD\_LC}$/$\overline{SD\_RC}$ pins. Driving the $\overline{SD\_LC}$/$\overline{SD\_RC}$ pins with active circuitry eliminates the pull-up resistor.

SELECTING PROPER EXTERNAL COMPONENTS

Optimizing the LM4926's performance requires properly selecting external components. Though the LM4926 operates well when using external components with wide tolerances, best performance is achieved by optimizing component values.

Charge Pump Capacitor Selection

Use low ESR (equivalent series resistance) (<100mΩ) ceramic capacitors with an X7R dielectric for best performance. Low ESR capacitors keep the charge pump output impedance to a minimum, extending the headroom on the negative supply. Higher ESR capacitors result in reduced output power from the audio amplifiers.

Charge pump load regulation and output impedance are affected by the value of the flying capacitor (C1). A larger valued C1 (up to 3.3uF) improves load regulation and minimizes charge pump output resistance. Beyond 3.3uF, the switch-on resistance dominates the output impedance for capacitor values above 2.2uF.

The output ripple is affected by the value and ESR of the output capacitor (C2). Larger capacitors reduce output ripple on the negative power supply. Lower ESR capacitors minimize the output ripple and reduce the output impedance of the charge pump.

The LM4926 charge pump design is optimized for 2.2uF, low ESR, ceramic, flying, and output capacitors.

Input Capacitor Value Selection

Amplifying the lowest audio frequencies requires high value input coupling capacitors (C_i in Figure 1). A high value capacitor can be expensive and may compromise space efficiency in portable designs. In many cases, however, the speakers used in portable systems, whether internal or external, have little ability to reproduce signals below 150Hz. Applications using speakers with this limited frequency response reap little improvement by using high value input and output capacitors.

Besides affecting system cost and size, C_i has an effect on the LM4926's click and pop performance. The magnitude of the pop is directly proportional to the input capacitor's size. Thus, pops can be minimized by selecting an input capacitor value that is no higher than necessary to meet the desired –3dB frequency.

As shown in Figure 1, the internal input resistor, R_i and the input capacitor, C_i, produce a -3dB high pass filter cutoff frequency that is found using Equation (3). Conventional headphone amplifiers require output capacitors; Equation (3) can be used, along with the value of R_L, to determine towards the value of output capacitor needed to produce a –3dB high pass filter cutoff frequency.

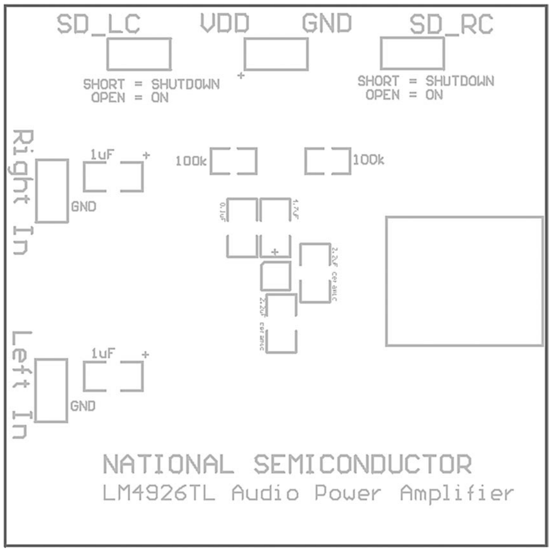
$$f_{i\text{-}3dB} = 1 / 2\pi R_i C_i \qquad (3)$$

Also, careful consideration must be taken in selecting a certain type of capacitor to be used in the system. Different types of capacitors (tantalum, electrolytic, ceramic) have unique performance characteristics and may affect overall system performance. (See the section entitled Charge Pump Capacitor Selection.)

Application Information (Continued)

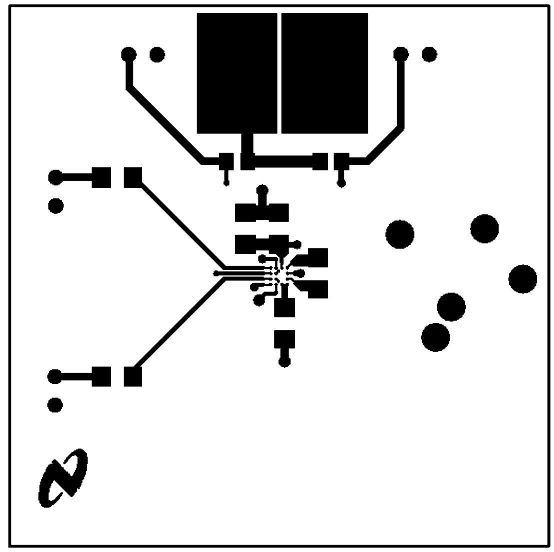
LM4926 micro SMD DEMO BOARD ARTWORK

Top Overlay



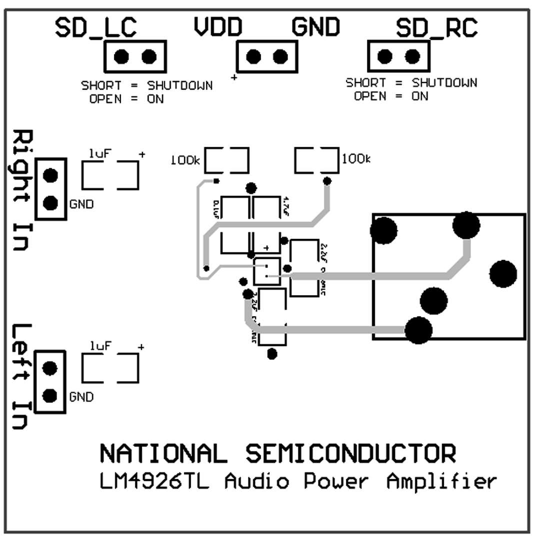
20116117

Top Layer



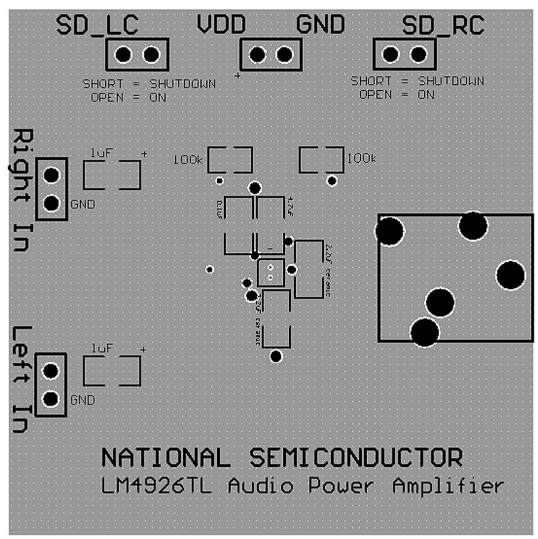
20116116

Mid Layer 1



201161H1

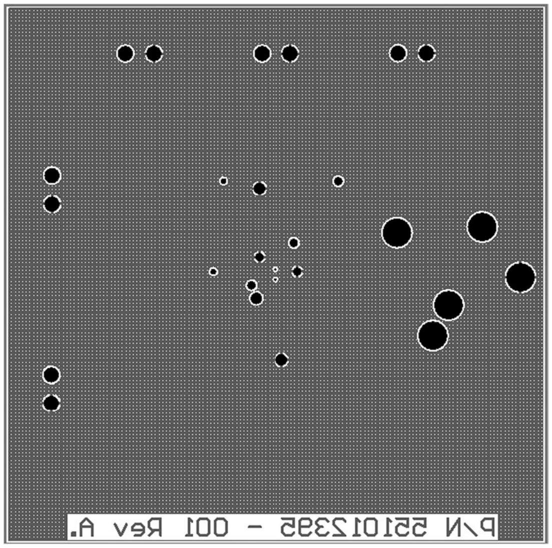
Mid Layer 2



201161H0

Application Information (Continued)

Bottom Layer

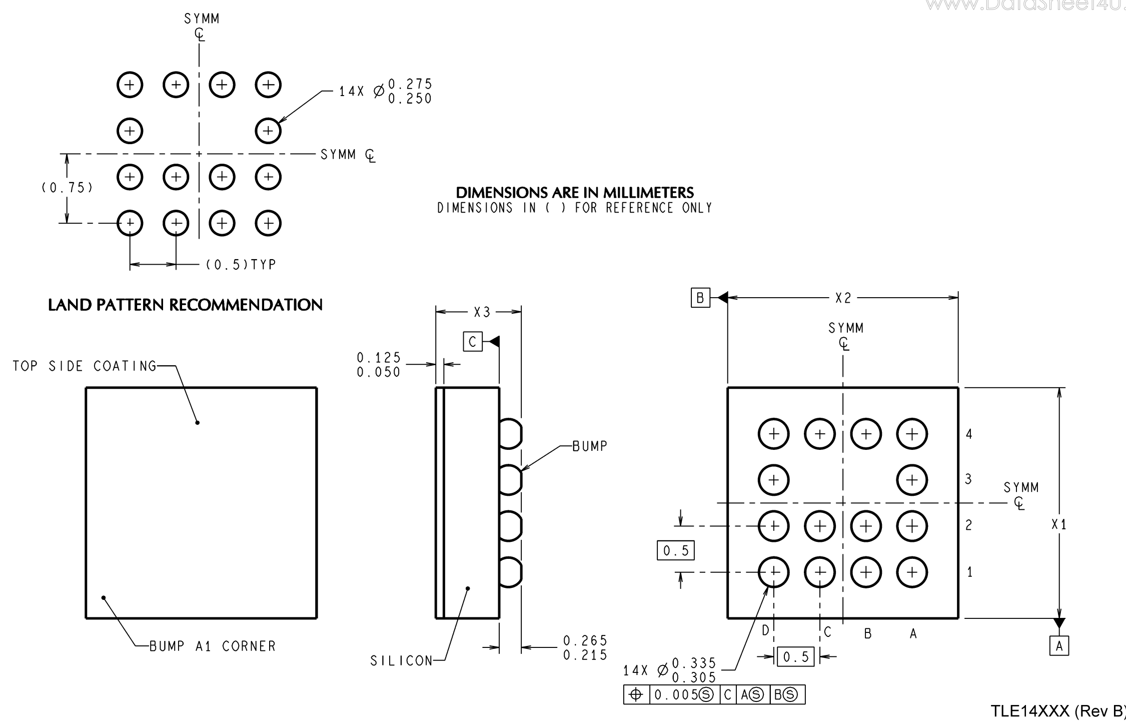


20116115

Revision History

Rev	Date	Description
1.0	6/22/05	Initial WEB release.
1.1	6/24/05	Added Mid Layer 1 and Mid Layer 2 boards, then re-released D/S to the WEB (per Nisha P.)

Physical Dimensions inches (millimeters) unless otherwise noted



TLE14XXX (Rev B)

14 – Bump micro SMD
Order Number LM4926TL
NS Package Number TLE1411A
X1 = 1.970±0.03mm, X2 = 1.970±0.03mm, X3 = 0.600±0.075mm,

National Semiconductor
Americas Customer
Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

www.national.com

National Semiconductor
Europe Customer Support Center
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor
Asia Pacific Customer
Support Center
Email: ap.support@nsc.com

National Semiconductor
Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560