# LM4819

LM4819 350mW Audio Power Amplifier with Shutdown Mode



Literature Number: SNAS133C



The LM4819 is a mono bridged power amplifier that is capable of delivering 350mW<sub>RMS</sub> output power into a 16 $\Omega$  load or 300mW<sub>RMS</sub> output power into an 8 $\Omega$  load with 10% THD+N from a 5V power supply.

The LM4819 Boomer audio power amplifier is designed specifically to provide high quality output power and minimize PCB area with surface mount packaging and a minimal amount of external components. Since the LM4819 does not require output coupling capacitors, bootstrap capacitors or snubber networks, it is optimally suited for low-power portable applications.

The closed loop response of the unity-gain stable LM4819 can be configured using external gain-setting resistors. The device is available in LLP, MSOP, and SO package types to suit various applications.

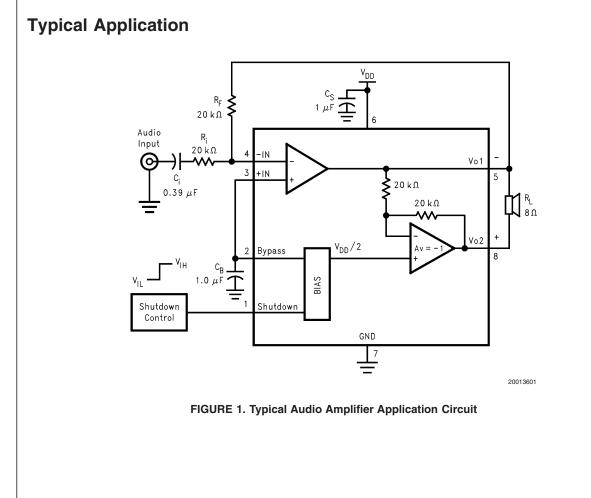
- THD+N at 1kHz, 350mW continuous average output power into 16Ω
   10% (max)
- THD+N at 1kHz, 300mW continuous average output power into 8Ω
   10% (max)
- Shutdown Current 0.7µA (typ)

# **Features**

- LLP, SOP, and MSOP surface mount packaging.
- Switch on/off click suppression.
- Unity-gain stable.
- Minimum external components.

# **Applications**

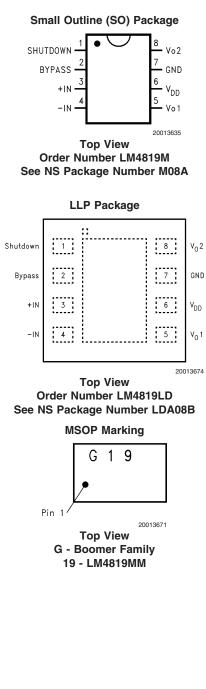
- General purpose audio
- Portable electronic devices
- Information Appliances (IA)

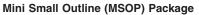


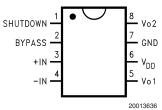
### Boomer® is a registered trademark of National Semiconductor Corporation.

April 2002

# **Connection Diagrams**

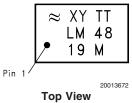






Top View Order Number LM4819MM See NS Package Number MUA08A





XY - Date Code TT - Die Traceability Bottom 2 lines - Part Number

# Absolute Maximum Ratings (Notes 2, 3)

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

Supply Voltage	6.0V
Storage Temperature	−65°C to +150°C
Input Voltage	–0.3V to V <sub>DD</sub> +0.3V
Power Dissipation $(P_D)$ (Note 4)	Internally Limited
ESD Susceptibility (Note 5)	3.5kV
ESD Susceptibility (Note 6)	250V
Junction Temperature (T <sub>J</sub> )	150°C
Soldering Information (Note 1)	
Small Outline Package	
Vapor Phase (60 seconds)	215°C

#### Infrared (15 seconds) 220°C Thermal Resistance θ<sub>IC</sub> (MSOP) 56°C/W θ<sub>JA</sub> (MSOP) 210°C/W $\theta_{JC}$ (SOP) 35°C/W $\theta_{IA}$ (SOP) 170°C/W $\theta_{JA}$ (LLP) 117°C/W (Note 10) $\theta_{IA}$ (LLP) 150°C/W (Note 11)

# **Operating Ratings** (Notes 2, 3)

Temperature Range	
$T_{MIN} \le T_A \le T_{MAX}$	$-40^{\circ}C \leq T_A \leq 85^{\circ}C$
Supply Voltage	$2.0V \le V_{CC} \le 5.5V$

**Electrical Characteristics**  $V_{DD} = 5V$  (Notes 2, 3) The following specifications apply for  $V_{DD} = 5V$ ,  $R_L = 16\Omega$  unless otherwise stated. Limits apply for  $T_A = 25^{\circ}C$ .

		Conditions	LM4819		
Symbol	Parameter		Typical	Limit	Units
			(Note 7)	(Notes 8, 9)	(Limits)
I <sub>DD</sub>	Quiescent Power Supply Current	$V_{IN} = 0V, I_o = 0A$	1.5	3.0	mA (max)
I <sub>SD</sub>	Shutdown Current	$V_{PIN1} = V_{DD}$ (Note 12)	1.0	5.0	μA (max)
V <sub>SDIH</sub>	Shutdown Voltage Input High			4.0	V (min)
V <sub>SDIL</sub>	Shutdown Voltage Input Low			1.0	V (max)
V <sub>os</sub>	Output Offset Voltage	V <sub>IN</sub> = 0V	5	50	mV (max)
Р	Output Bower	THD = 10%, f <sub>IN</sub> = 1kHz	350		mW
Po	Output Power	THD = 10%, $f_{IN} = 1$ kHz, $R_L = 8\Omega$	300		mW
THD+N	Total Harmonic Distortion + Noise	$P_{O} = 270 \text{mW}_{\text{RMS}}, A_{VD} = 2, f_{\text{IN}} =$	1		%
		1kHz			

**Electrical Characteristics**  $V_{DD} = 3V$  (Notes 2, 3) The following specifications apply for  $V_{DD} = 3V$  and  $R_L = 16\Omega$  load unless otherwise stated. Limits apply to  $T_A = 25^{\circ}C$ .

		Conditions	LM4819		
Symbol	Parameter		Typical	Limit (Notes 8, 9)	Units (Limits)
			(Note 7)		
I <sub>DD</sub>	Quiescent Power Supply Current	$V_{IN} = 0V, I_o = 0A$	1.0	3.0	mA (max)
I <sub>SD</sub>	Shutdown Current	V <sub>PIN1</sub> = V <sub>DD</sub> (Note 12)	0.7	5.0	μA (max)
V <sub>SDIH</sub>	Shutdown Voltage Input High			2.4	V (min)
V <sub>SDIL</sub>	Shutdown Voltage Input Low			0.6	V (max)
V <sub>os</sub>	Output Offset Voltage	$V_{IN} = 0V$	5	50	mV
	Output Power	THD = 10%, f <sub>IN</sub> = 1kHz	110		mW
Po		THD = 10%, $f_{IN} = 1$ kHz, $R_L = 8\Omega$	90		mW
THD+N	Total Harmonic Distortion + Noise	$P_O = 80 \text{mW}_{\text{RMS}}, A_{VD} = 2, f_{\text{IN}} = 1 \text{kHz}$	1		%

Note 1: See AN-450 "Surface Mounting and their Effects on Product Reliability" for other methods of soldering surface mount devices.

Note 2: All voltages are measured with respect to the ground pin, unless otherwise specified.

Note 3: 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 which 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's performance.

Note 4: The maximum power dissipation must be derated at elevated temperatures and is dictated by TJMAX,  $\theta_{JA}$ , and the ambient temperature TA. The maximum allowable power dissipation is  $P_{DMAX} = (T_{JMAX} - T_A)/\theta_{JA}$ . For the LM4819,  $T_{JMAX} = 150^{\circ}C$  and the typical junction-to-ambient thermal resistance ( $\theta_{JA}$ ) when board mounted is 210°C/W for the MSOP package and 170°C/W for the SOP package.

**Note 5:** Human body model, 100pF discharged through a 1.5 k $\Omega$  resistor.

**Electrical Characteristics**  $V_{DD}$  = **3V** (Notes 2, 3) The following specifications apply for  $V_{DD}$  = 3V and  $R_L$  = 16 $\Omega$  load unless otherwise stated. Limits apply to  $T_A$  = 25°C. (Continued)

Note 6: Machine Model, 220pF-240pF capacitor is discharged through all pins.

Note 7: Typical specifications are specified at 25°C and represent the parametric norm.

Note 8: Tested limits are guaranteed to National's AOQL (Average Outgoing Quality Level).

Note 9: Datasheet min/max specification limits are guaranteed by designs, test, or statistical analysis.

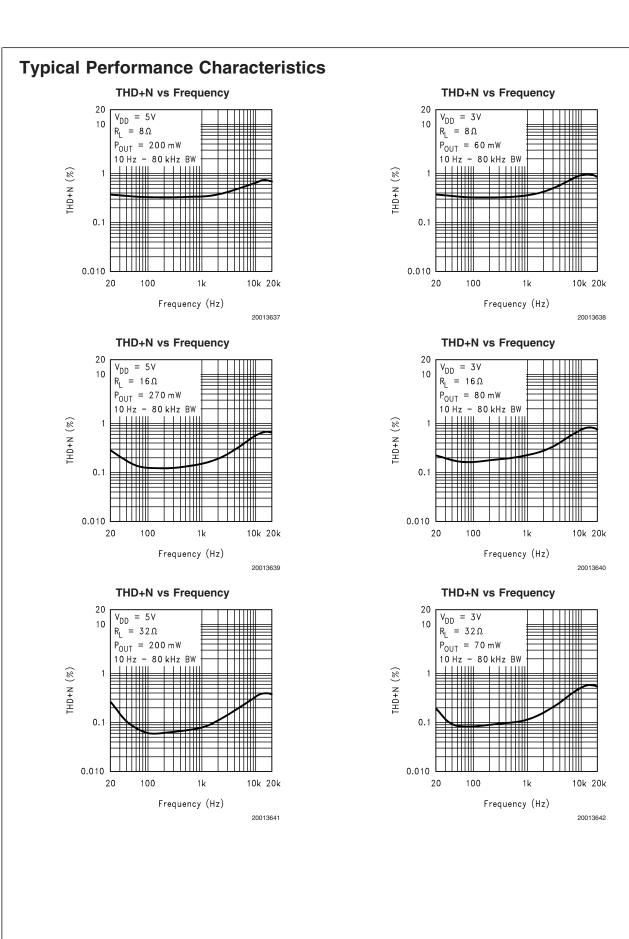
Note 10: The given  $\theta_{JA}$  is for an LM4819 package in an LDA08B with the Exposed-DAP soldered to a printed circuit board copper pad with an area equivalent to that of the Exposed-DAP itself. The Exposed-DAP of the LDA08B package should be electrically connected to GND or an electrically isolated copper area.

Note 11: The given  $\theta_{JA}$  is for an LM4819 package in an LDA08B with the Exposed-DAP not soldered to any printed circuit board copper.

Note 12: The shutdown pin (pin1) should be driven as close as possible to V<sub>DD</sub> for minimum current in Shutdown Mode.

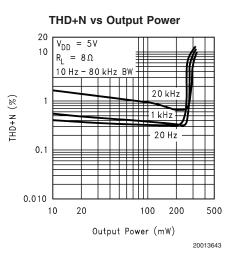
# External Components Description (Figure 1)

Components		Functional Description		
1.	R <sub>i</sub>	Combined with R <sub>f</sub> , this inverting input resistor sets the closed-loop gain. R <sub>i</sub> also forms a high pass filter with		
		$C_i$ at $f_c = 1/(2\pi R_i C_i)$ .		
2.	Ci	This input coupling capacitor blocks DC voltage at the amplifier's terminals. Combined with R <sub>i</sub> , it creates a		
		high pass filter with $R_i$ at $f_c = 1/(2\pi R_i C_i)$ . Refer to the section, <b>Proper Selection of External Components</b> for		
		an explanation of how to determine the value of C <sub>i</sub> .		
3.	R <sub>f</sub>	Combined with $R_i$ , this is the feedback resistor that sets the closed-loop gain: $A_v = 2(R_F/R_i)$ .		
4.	Cs	This is the power supply bypass capacitor that filters the voltage applied to the power supply pin. Refer to the		
		Application Information section for proper placement and selection of C <sub>s</sub> .		
5.	CB	This is the bypass pin capacitor that filters the voltage at the BYPASS pin. Refer to the section, Proper		
		Selection of External Components, for information concerning proper placement and selection of C <sub>B</sub> .		

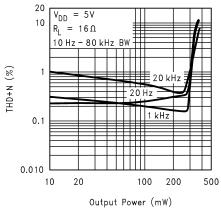




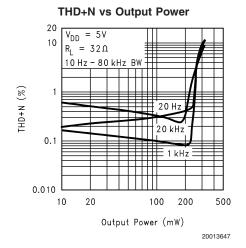
# Typical Performance Characteristics (Continued)

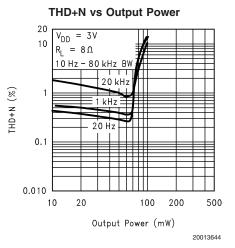




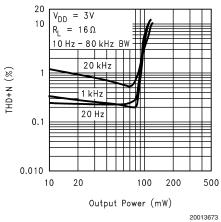


20013645

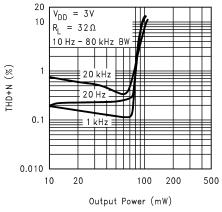


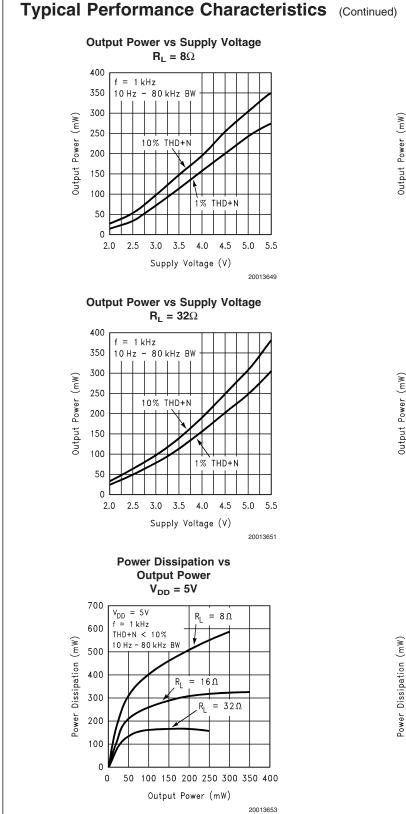


THD+N vs Output Power

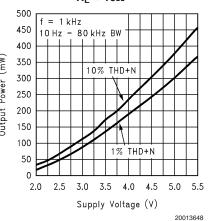


THD+N vs Output Power

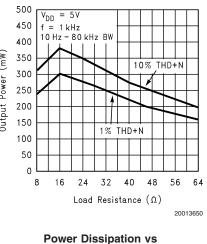


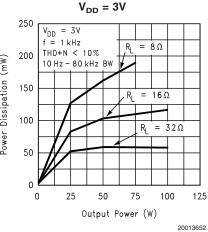


Output Power vs Supply Voltage  $\textbf{R}_{\textbf{L}} = \textbf{16} \boldsymbol{\Omega}$ 



**Output Power vs Load Resistance** 



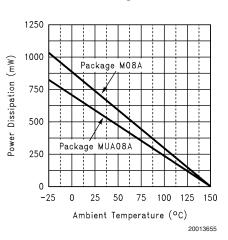


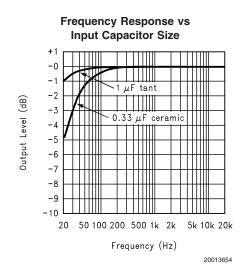
**Output Power** 

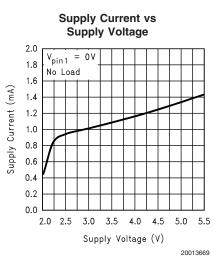
LM4819

# Typical Performance Characteristics (Continued)

# **Power Derating Curves**







# **Application Information**

## **BRIDGE CONFIGURATION EXPLANATION**

As shown in *Figure 1*, the LM4819 consist of two operational amplifiers. External resistors, R<sub>i</sub> and R<sub>F</sub> set the closed-loop gain of the first amplifier (and the amplifier overall), whereas two internal  $20k\Omega$  resistors set the second amplifier's gain at -1. The LM4819 is typically used to drive a speaker connected between the two amplifier outputs.

*Figure 1* shows that the output of Amp1 servers as the input to Amp2, which results in both amplifiers producing signals identical in magnitude but 180° out of phase. Taking advantage of this phase difference, a load is placed between  $V_{01}$  and  $V_{02}$  and driven differentially (commonly referred to as "bridge mode"). This results in a differential gain of

$$A_{VD} = 2 (R_f/R_i)$$
 (1)

Bridge mode is different from single-ended amplifiers that drive loads connected between a single amplifier's output and ground. For a given supply voltage, bridge mode has a distinct advantage over the single-ended configuration: its differential output doubles the voltage swing across the load. This results in four times the output power when compared to a single-ended amplifier under the same conditions. This increase in attainable output assumes that the amplifier is not current limited or the output signal is not clipped. To ensure minimum output signal clipping when choosing an amplifier's closed-loop gain, refer to the **Audio Power Amplifier Design Example** section.

Another advantage of the differential bridge output is no net DC voltage across the load. This results from biasing  $V_{01}$  and  $V_{02}$  at half-supply. This eliminates the coupling capacitor that single supply, single-ended amplifiers require. Eliminating an output coupling capacitor in a single-ended configuration forces a single supply amplifier's half-supply bias voltage across the load. The current flow created by the half-supply bias voltage increases internal IC power dissipation and may permanently damage loads such as speakers.

# POWER DISSIPATION

Power dissipation is a major concern when designing a successful bridged or single-ended amplifier. Equation (2) states the maximum power dissipation point for a single-ended amplifier operating at a given supply voltage and driving a specified load.

$$P_{\text{DMAX}} = (V_{\text{DD}})^2 / (2\pi^2 R_L)$$
 (W) Single-ended (2)

However, a direct consequence of the increased power delivered to the load by a bridged amplifier is an increase in the internal power dissipation point for a bridge amplifier operating at the same given conditions. Equation (3) states the maximum power dissipation point for a bridged amplifier operating at a given supply voltage and driving a specified load.

$$P_{DMAX} = 4(V_{DD})^2/(2\pi^2 R_L)$$
 (W) Bridge Mode (3)

The LM4819 has two operational amplifiers in one package and the maximum internal power dissipation is four times that of a single-ended amplifier. However, even with this substantial increase in power dissipation, the Lm4819 does not require heatsinking. From Equation (3), assuming a 5V power supply and an 8 $\Omega$  load, the maximum power dissipation point is 633mW. The maximum power dissipation point obtained from Equation (3) must not exceed the power dissipation predicted by Equation (4):

$$P_{DMAX} = (T_{JMAX} - T_A)/\theta_{JA} (W)$$
(4)

For the micro MUA08A package,  $\theta_{JA} = 210^{\circ}C/W$ , for the M08A package,  $\theta_{JA} = 170^{\circ}C/W$ , and  $T_{JMAX} = 150^{\circ}C$  for the LM4819. For a given ambient temperature,  $T_A$ , Equation (4) can be used to find the maximum internal power dissipation supported by the IC packaging. If the result of Equation (3) is greater than the result of Equation (4), then decrease the supply voltage, increase the load impedance, or reduce the ambient temperature. For a typical application using the M08A packaged LM4819 with a 5V power supply and an  $8\Omega$ load, the maximum ambient temperature that does not violate the maximum junction temperature is approximately 42°C. If a MUA08A packaged part is used instead with the same supply voltage and load, the maximum ambient temperature is 17°C. In both cases, it is assumed that a device is a surface mount part operating around the maximum power dissipation point. The assumption that the device is operating around the maximum power dissipation point is incorrect for an  $8\Omega$  load. The maximum power dissipation point occurs when the output power is equal to the maximum power dissipation or 50% efficiency. The LM4819 is not capable of the output power level (633mW) required to operate at the maximum power dissipation point for an  $8\Omega$  load. To find the maximum power dissipation, the graph Power Dissipation vs. Output Power must be used. From the graph, the maximum power dissipation for an  $8\Omega$  load and a 5V supply is approximately 575mW. Substituting this value back into equation (4) for  $P_{DMAX}$  and using  $\theta_{JA} = 210^{\circ}C/W$ for the MUA08A package, the maximum ambient temperature is calculated to be 29°C. Using  $\theta_{JA} = 170^{\circ}$ C/W for the M08A package, the maximum ambient temperature is 52°C. Refer to the Typical Performance Characteristics curves for power dissipation information for lower output powers and maximum power dissipation for each package at a given

#### POWER SUPPLY BYPASSING

ambient temperature.

As with any power amplifier, proper supply bypassing is critical for low noise performance and high power supply rejection. The capacitors connected to the bypass and power supply pins should be placed as close to the LM4819 as possible. The capacitor connected between the bypass pin and ground improves the internal bias voltage's stability, producing improved PSRR. The improvements to PSRR increase as the bypass pin capacitor value increases. Typical applications employ a 5V regulator with 10µF and 0.1µF filter capacitors that aid in supply stability. Their presence, however, does not eliminate the need for bypassing the supply nodes of the LM4819. The selection of bypass capacitor values, especially  $\mathrm{C}_{\mathrm{B}}$  , depends on desired PSRR requirements, click and pop performance as explained in the section, Proper Selection of External Components, as well as system cost and size constraints.

#### SHUTDOWN FUNCTION

The voltage applied to the LM4819's SHUTDOWN pin controls the shutdown function. Activate micro-power shutdown by applying  $V_{DD}$  to the SHUTDOWN pin. When active, the LM4819's micro-power shutdown feature turns off the amplifier's bias circuitry, reducing the supply current. The logic threshold is typically  $1/2V_{DD}$ . The low  $0.7\mu$ A typical shutdown current is achieved by applying a voltage that is as near as  $V_{DD}$  as possible to the SHUTDOWN pin. A voltage that is less than  $V_{DD}$  may increase the shutdown current. Avoid intermittent or unexpected micro-power shutdown by ensuring that the SHUTDOWN pin is not left floating but connected to either  $V_{DD}$  or GND.

There are a few ways to activate micro-power shutdown. These included using a single-pole, single-throw switch, a microcontroller, or a microprocessor. When using a switch, connect an external  $10k\Omega$  to  $100k\Omega$  pull-up resistor between the SHUTDOWN pin and  $V_{DD}$ . Connect the switch between the SHUTDOWN pin and ground. Select normal amplifier operation by closing the switch. Opening the switch connects the shutdown pin to  $V_{DD}$  through the pull-up resistor, activating micro-power shutdown. The switch and resistor guarantee that the SHUTDOWN pin will not float. This prevents unwanted state changes. In a system with a microprocessor or a microcontroller, use a digital output to apply the control voltage to the SHUTDOWN pin. Driving the SHUTDOWN pin with active circuitry eliminates the pull-up resistor

#### PROPER SELECTION OF EXTERNAL COMPONENTS

Optimizing the LM4819's performance requires properly selecting external components. Though the LM4819 operates well when using external components with wide tolerances, best performance is achieved by optimizing component values.

The LM4819 is unity gain stable, giving the designer maximum design flexibility. The gain should be set to no more than a given application requires. This allows the amplifier to achieve minimum THD+N and maximum signal-to-noise ratio. These parameters are compromised as the closed-loop gain increases. However, low gain demands input signals with greater voltage swings to achieve maximum output power. Fortunately, many signal sources such as audio CO-DECs have outputs of  $1V_{RMS}$  (2.83V<sub>P-P</sub>). Please refer to the **Audio Power Amplifier Design** section for more information on selecting the proper gain.

Another important consideration is the amplifier's close-loop bandwidth. To a large extent, the bandwidth is dictated by the choice of external components shown in *Figure 1*. The input coupling capacitor,  $C_{i}$ , forms a first order high pass filter that limits low frequency response. This value should be chosen based on needed frequency response for a few distinct reasons discussed below

#### Input Capacitor Value Selection

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

Besides affecting system cost and size, C<sub>i</sub> has an effect on the LM4819's click and pop performance. When the supply voltage is first applied, a transient (pop) is created as the charge on the input capacitor changes from zero to a quiescent state. The magnitude of the pop is directly proportional to the input capacitor's value. Higher value capacitors need more time to reach a quiescent DC voltage (usually 1/2 V<sub>DD</sub>) when charged with a fixed current. The amplifier's output charges the input capacitor through the feedback resistor, R<sub>F</sub>. Thus, selecting an input capacitor value that is no higher than necessary to meet the desired -3dB frequency can minimize pops.

As shown in *Figure 1*, the input resistor ( $R_i$ ) and the input capacitor,  $C_i$  produce a -3dB high pass filter cutoff frequency that is found using Equation (5).

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

As an example when using a speaker with a low frequency limit of 150Hz, C<sub>i</sub>, using Equation (5) is  $0.063\mu$ F. The  $0.39\mu$ F C<sub>i</sub> shown in *Figure 1* allows the LM4819 to drive a high efficiency, full range speaker whose response extends down to 20Hz.

Besides optimizing the input capacitor value, the bypass capacitor value,  $C_B$  requires careful consideration. The bypass capacitor's value is the most critical to minimizing turn-on pops because it determines how fast the LM4819 turns on. The slower the LM4819's outputs ramp to their quiescent DC voltage (nominally  $1/2V_{DD}$ ), the smaller the turn-on pop. While the device will function properly (no oscillations or motorboating), with  $C_B$  less than  $1.0\mu$ F, the device will be much more susceptible to turn-on clicks and pops. Thus, a value of  $C_B$  equal to or greater than  $1.0\mu$ F is recommended in all but the most cost sensitive designs.

#### **Bypass Capacitor Value Selection**

Besides minimizing the input capacitor size, careful consideration should be paid to the value of  $C_B$ , the capacitor connected to the BYPASS pin. Since  $C_B$  determines how fast the LM4819 settles to quiescent operation, its value is critical when minimizing turn-on pops. The slower the LM4819's outputs ramp to their quiescent DC voltage (nominally  $1/2V_{DD}$ ), the smaller the turn-on pop. Choosing  $C_B$  equal to  $1.0\mu$ F along with a small value of  $C_i$  (in the range of  $0.1\mu$ F to  $0.39\mu$ F) produces a click-less and pop-less shutdown function. As discussed above, choosing  $C_i$  no larger than necessary for the desired bandwidth helps minimize clicks and pops.

#### **Optimizing Click and Pop Reduction Performance**

The LM4819 contains circuitry that minimizes turn-on and shutdown transients or "clicks and pops". For this discussion, turn on refers to either applying the power or supply voltage or when the shutdown mode is deactivated. While the power supply is ramping to it's final value, the LM4819's internal amplifiers are configured as unity gain buffers. An internal current source charges the voltage of the bypass capacitor, C<sub>B</sub>, connected to the BYPASS pin in a controlled, linear manner. Ideally, the input and outputs track the voltage charging on the bypass capacitor. The gain of the internal amplifiers remains unity until the bypass capacitor is fully charged to  $1/2V_{\mbox{\scriptsize DD}}.$  As soon as the voltage on the bypass capacitor is stable, the device becomes fully operational. Although the BYPASS pin current cannot be modified, changing the size of the bypass capacitor, C<sub>B</sub>, alters the device's turn-on time and magnitude of "clicks and pops". Increasing the value of  $C_{\rm B}$  reduces the magnitude of turn-on pops. However, this presents a tradeoff: as the size of  $C_B$ increases, the turn-on time (Ton) increases. There is a linear relationship between the size of  $C_B$  and the turn on time. Below are some typical turn-on times for various values of C<sub>B</sub>:

С <sub>в</sub>	T <sub>ON</sub>
0.01µF	20ms
0.1µF	200ms
0.22µF	440ms
0.47µF	940ms
1.0µF	2S

In order to eliminate "clicks and pops", all capacitors must be discharged before turn-on. Rapidly switching  $V_{\rm DD}$  may not allow the capacitors to fully discharge, which may cause "clicks and pops".

#### AUDIO POWER AMPLIFIER DESIGN EXAMPLE

# The following are the desired operational parameters:

Given:

Power Output	100mW
Load Impedance	<b>16</b> Ω
Input Level	1Vrms (max)
Input Impedance	20kΩ
Bandwidth	100Hz–20kHz ± 0.25dB

The design begins by specifying the minimum supply voltage necessary to obtain the specified output power. To find this minimum supply voltage, use the **Output Power vs. Supply Voltage** graph in the **Typical Performance Characteristics** section. From the graph for a 16 $\Omega$  load, (graphs are for 8 $\Omega$ , 16 $\Omega$ , and 32 $\Omega$  loads) the supply voltage for 100mW of output power with 1% THD+N is approximately 3.15 volts.

Additional supply voltage creates the benefit of increased headroom that allows the LM4819 to reproduce peaks in excess of 100mW without output signal clipping or audible distortion. The choice of supply voltage must also not create a situation that violates maximum dissipation as explained above in the **Power Dissipation** section. For example, if a 3.3V supply is chosen for extra headroom then according to Equation (3) the maximum power dissipation point with a 16 $\Omega$  load is 138mW. Using Equation (4) the maximum ambient temperature is 121°C for the MUA08A package and 126°C for the M08A package.

After satisfying the LM4819's power dissipation requirements, the minimum differential gain is found using Equation (6).

$$\rm A_{VD} \geq \sqrt{(P_{0}R_{L})}/(V_{IN}) = V_{orms}/V_{inrms}$$

Thus a minimum gain of 1.27 V/V allows the LM4819 to reach full output swing and maintain low noise and THD+N performance. For this example, let  $A_{VD} = 1.27$ . The amplifier's overall gain is set using the input ( $R_i$ ) and feedback ( $R_F$ ) resistors. With the desired input impedance set to  $20k\Omega$ , the feedback resistor is found using Equation (7).

$$R_{\rm F}/R_{\rm i} = A_{\rm VD}/2 \ ({\rm V}/{\rm V}) \tag{7}$$

The value of  $R_F$  is 13k $\Omega$ .

The last step in this design example is setting the amplifier's -3dB frequency bandwidth. To achieve the desired  $\pm 0.25dB$  pass band magnitude variation limit, the low frequency response must extend to at least one-fifth the lower bandwidth limit and the high frequency response must extend to at least five times the upper bandwidth limit. The gain variation for both response limits is 0.17dB, well with in the  $\pm 0.25dB$  desired limit.

The results are:

$$f_L = 100Hz/5 = 20Hz$$
  
 $f_H = 20 \text{ kHz}*5 = 100\text{ kHz}$ 

As mentioned in the **External Components** section,  $R_i$  and  $C_i$  create a high pass filter that sets the amplifier's lower band pass frequency limit. Find the coupling capacitor's value using Equation (8).

$$C_i \ge 1/(2\pi R_i f_c) (F)$$
(8)

 $C_i \geq 0.398 \mu F$ , a standard value of  $0.39 \mu F$  will be used. The product of the desired high frequency cutoff (100kHz in this example) and the differential gain,  $A_{VD}$ , determines the upper pass band response limit. With  $A_{VD}$  = 1.27 and  $f_{\rm H}$  = 100kHz, the closed-loop gain bandwidth product (GBWP) is 127kHz. This is less than the LM4819's 900kHz GBWP. With this margin the amplifier can be used in designs that require more differential gain while avoiding performance restricting bandwidth limitations.

(6)

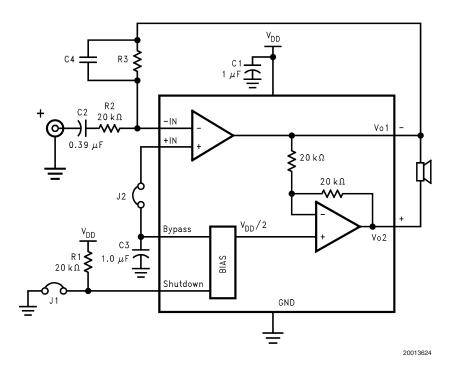


FIGURE 2. HIGHER GAIN AUDIO AMPLIFIER

The LM4819 is unity-gain stable and requires no external components besides gain-setting resistors, an input coupling capacitor, and proper supply bypassing in the typical application. However, if a closed-loop differential gain of greater than 10 is required, a feedback capacitor ( $C_4$ ) may be needed as shown in Figure 2 to bandwidth limit the amplifier. This feedback capacitor creates a low pass filter that eliminates possible high frequency oscillations. Care should be

taken when calculating the -3dB frequency in that an incorrect combination of R<sub>3</sub> and C<sub>4</sub> will cause rolloff before 20kHz. A typical combination of feedback resistor and capacitor that will not produce audio band high frequency rolloff is R<sub>3</sub> = 20k $\Omega$  and C<sub>4</sub> = 25pF. These components result in a -3dB point of approximately 320 kHz. It is not recommended that the feedback resistor and capacitor be used to implement a band limiting filter below 100kHz.

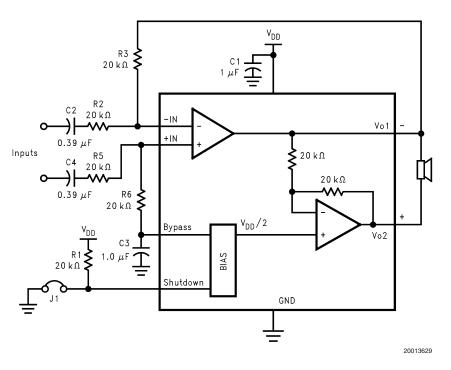


FIGURE 3. DIFFERENTIAL AMPLIFIER CONFIGURATION FOR LM4819

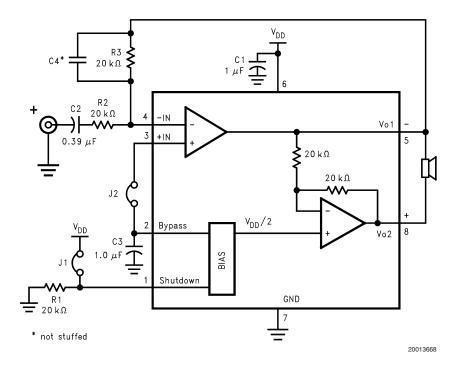
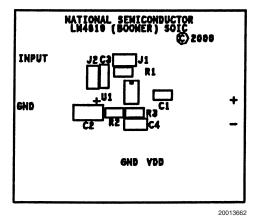


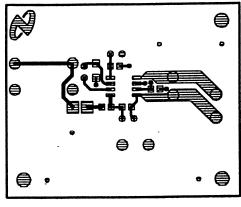
FIGURE 4. REFERENCE DESIGN BOARD and PCB LAYOUT GUIDELINES

# LM4819 SO DEMO BOARD ARTWORK

Silk Screen

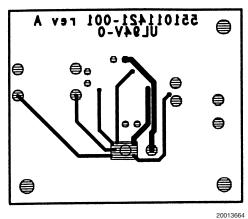


Top Layer

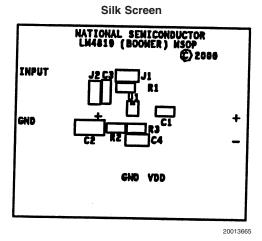


20013663

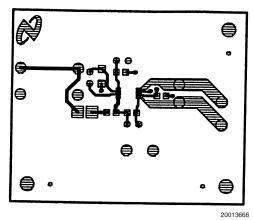
**Bottom Layer** 



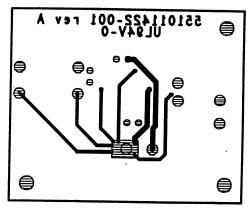
# LM4819 MSOP DEMO BOARD ARTWORK



# Top Layer



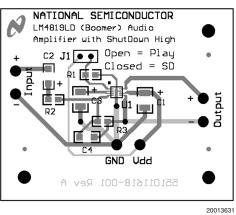
#### **Bottom Layer**



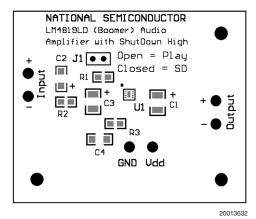
20013667

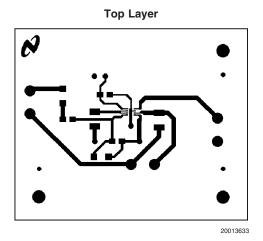
# LM4819 LD DEMO BOARD ARTWORK



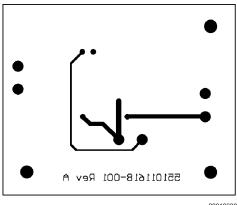








Bottom Layer



20013630

#### Mono LM4819 Reference Design Boards Bill of Material for all Demo Boards

Item	Part Number	Part Description	Qty	Ref Designator
1	551011208-001	LM4819 Mono Reference Design Board	1	
10	482911183-001	LM4819 Audio AMP	1	U1
20	151911207-001	Tant Cap 1uF 16V 10	1	C1
21	151911207-002	Cer Cap 0.39uF 50V Z5U 20% 1210	1	C2
25	152911207-001	Tant Cap 1uF 16V 10	1	C3
30	472911207-001	Res 20K Ohm 1/10W 5	3	R1, R2, R3
35	210007039-002	Jumper Header Vertical Mount 2X1 0.100	2	J1, J2

# LM4819

# Application Information (Continued)

# PCB LAYOUT GUIDELINES

This section provides practical guidelines for mixed signal PCB layout that involves various digital/analog power and ground traces. Designers should note that these are only "rule-of-thumb" recommendations and the actual results will depend heavily on the final layout.

#### **General Mixed Signal Layout Recommendation**

### **Power and Ground Circuits**

For two layer mixed signal design, it is important to isolate the digital power and ground trace paths from the analog power and ground trace paths. Star trace routing techniques (bringing individual traces back to a central point rather than daisy chaining traces together in a serial manner) can have a major impact on low level signal performance. Star trace routing refers to using individual traces to feed power and ground to each circuit or even device. This technique will take require a greater amount of design time but will not increase the final price of the board. The only extra parts required will be some jumpers.

# Single-Point Power / Ground Connections

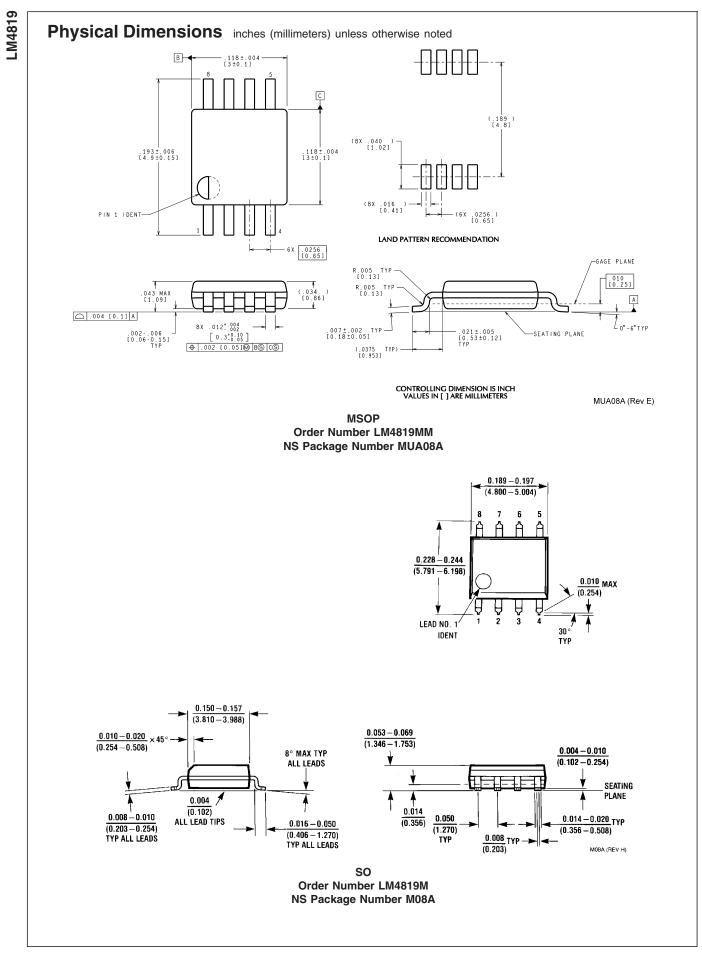
The analog power traces should be connected to the digital traces through a single point (link). A "Pi-filter" can be helpful in minimizing high frequency noise coupling between the analog and digital sections. It is further recommended to put digital and analog power traces over the corresponding digital and analog ground traces to minimize noise coupling.

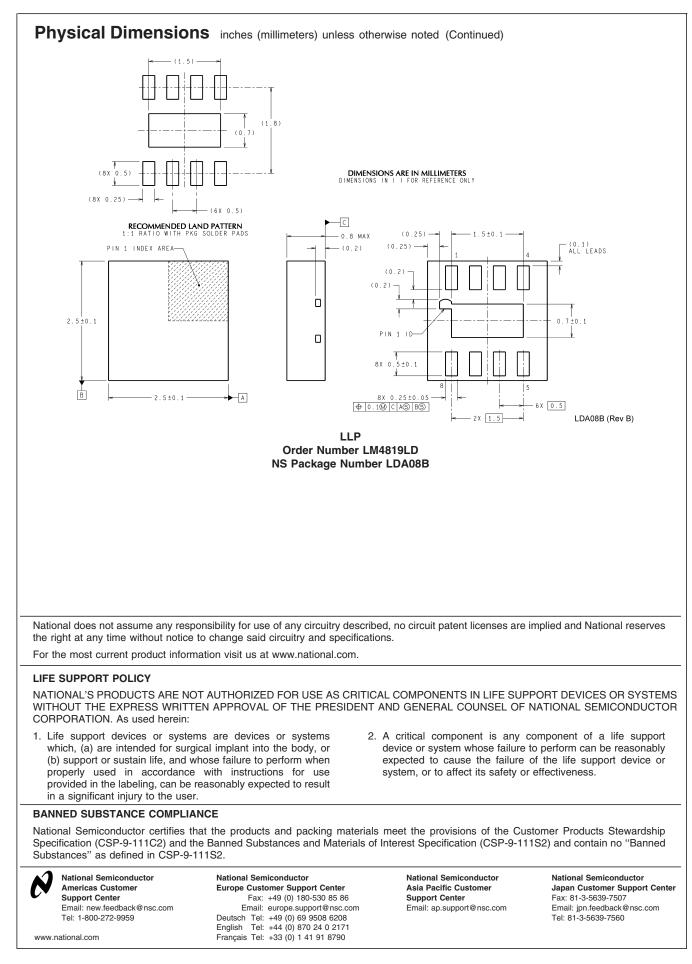
### **Placement of Digital and Analog Components**

All digital components and high-speed digital signals traces should be located as far away as possible from analog components and circuit traces.

# Avoiding Typical Design / Layout Problems

Avoid ground loops or running digital and analog traces parallel to each other (side-by-side) on the same PCB layer. When traces must cross over each other do it at 90 degrees. Running digital and analog traces at 90 degrees to each other from the top to the bottom side as much as possible will minimize capacitive noise coupling and cross talk.





### **IMPORTANT NOTICE**

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Audio	www.ti.com/audio	Communications and Telecom	www.ti.com/communications
Amplifiers	amplifier.ti.com	Computers and Peripherals	www.ti.com/computers
Data Converters	dataconverter.ti.com	Consumer Electronics	www.ti.com/consumer-apps
DLP® Products	www.dlp.com	Energy and Lighting	www.ti.com/energy
DSP	dsp.ti.com	Industrial	www.ti.com/industrial
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Security	www.ti.com/security
Logic	logic.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Power Mgmt	power.ti.com	Transportation and Automotive	www.ti.com/automotive
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Mobile Processors	www.ti.com/omap		
Wireless Connectivity	www.ti.com/wirelessconnectivity		
		u Hama Dawa	a O a Al a a m

**TI E2E Community Home Page** 

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265 Copyright © 2011, Texas Instruments Incorporated