National Semiconductor

October 2001

LM4894 Boomer® Audio Power Amplifier Series

1 Watt Fully Differential Audio Power Amplifier With Shutdown Select

General Description

The LM4894 is a fully differential audio power amplifier primarily designed for demanding applications in mobile phones and other portable communication device applications. It is capable of delivering 1 watt of continuous average power to an 8Ω BTL load with less than 1% distortion (THD+N) from a $5V_{DC}$ power supply.

Boomer audio power amplifiers were designed specifically to provide high quality output power with a minimal amount of external components. The LM4894 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 LM4894 features a low-power consumption shutdown mode. To facilitate this, Shutdown may be enabled by either logic high or low depending on mode selection. Driving the shutdown mode pin either high or low enables the shutdown select pin to be driven in a likewise manner to enable Shutdown. Additionally, the LM4894 features an internal thermal shutdown protection mechanism.

The LM4894 contains advanced pop & click circuitry which eliminates noises which would otherwise occur during turn-on and turn-off transitions.

The LM4894 is unity-gain stable and can be configured by external gain-setting resistors.

Key Specifications

- Improved PSRR at 217Hz 80dB(typ)
- Power Output at 5.0V & 1% THD 1.0W(typ)
- Power Output at 3.3V & 1% THD 400mW(typ)
- Shutdown Current 0.1µA(typ)

Features

- Fully differential amplification
- Available in space-saving packages micro SMD, MSOP, and LLP
- Ultra low current shutdown mode
- Can drive capacitive loads up to 500 pF
- Improved pop & click circuitry eliminates noises during turn-on and turn-off transitions
- 2.2 - 5.5V operation
- No output coupling capacitors, snubber networks or bootstrap capacitors required
- Unity-gain stable
- External gain configuration capability
- Shutdown high or low selectivity
- High CMRR

Applications

- Mobile phones
- PDAs
- Portable electronic devices

Typical Application

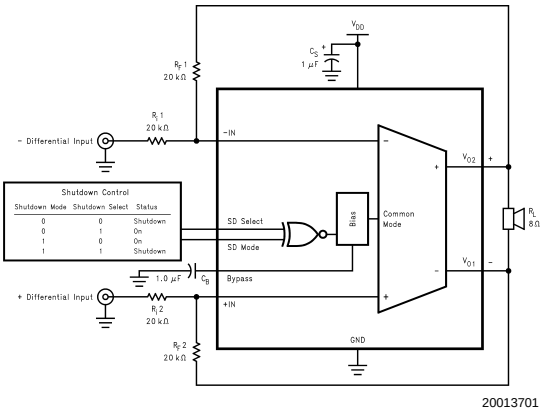

FIGURE 1. Typical Audio Amplifier Application Circuit

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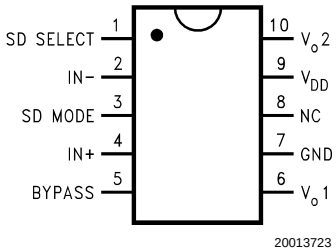
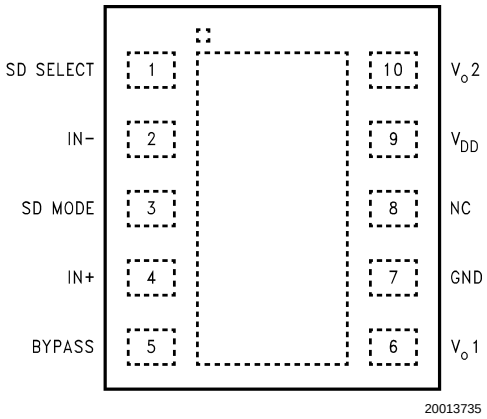
Connection Diagrams

Mini Small Outline (MSOP) Package



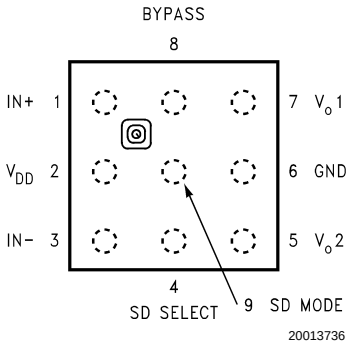
Top View
Order Number LM4894MM
See NS Package Number MUB10A

LLP Package



Top View
Order Number LM4894LD
See NS Package Number LDA10B

9 Bump micro SMD Package



Top View
Order Number LM4894IBP
See NS Package Number BPA09CDB

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	6.0V
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_{JC} (LLP)	12˚C/W
θ_{JA} (LLP)	63˚C/W
θ_{JA} (micro SMD)	220˚C/W
θ_{JC} (MSOP)	56˚C/W
θ_{JA} (MSOP)	190˚C/W

Soldering Information

See AN-1112 'microSMD Wafers Level Chip Scale Package.'

See AN-1187 'Leadless Leadframe Package (LLP).'

Operating Ratings

Temperature Range	
$T_{MIN} \le T_A \le T_{MAX}$	−40˚C ≤ T_A ≤ 85˚C
Supply Voltage	2.2V ≤ V_{DD} ≤ 5.5V

Electrical Characteristics V_{DD} = 5V

(Notes 1, 2, 8)

The following specifications apply for V_{DD} = 5V, A_V = 1, and 8Ω load unless otherwise specified. Limits apply for T_A = 25˚C.

Symbol	Parameter	Conditions	LM4894		Units (Limits)
			Typical (Note 6)	Limit (Note 7)	
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0V, I_o = 0A	4	8	mA (max)
I_{SD}	Shutdown Current	$V_{\overline{shutdown}}$ = GND	0.1	1	µA (max)
P_o	Output Power	THD = 1% (max); f = 1 kHz			
		LM4894LD, R_L= 4Ω (Note 11)	1.4		W (min)
		LM4894, R_L= 8Ω	1	0.850	
THD+N	Total Harmonic Distortion+Noise	P_o = 0.4 Wrms; f = 1kHz	0.1		%
PSRR	Power Supply Rejection Ratio	V_{ripple} = 200mV sine p-p			
		f = 217Hz (Note 9)	87		dB
		f = 1kHz (Note 9)	83		
		f = 217Hz (Note 10)	83		
		f = 1kHz (Note 10)	80		
CMRR	Common_Mode Rejection Ratio	f = 217Hz	50		dB

Electrical Characteristics V_{DD} = 3V (Notes 1, 2, 8)

The following specifications apply for V_{DD} = 3V, A_V = 1, and 8Ω load unless otherwise specified. Limits apply for T_A = 25˚C.

Symbol	Parameter	Conditions	LM4894		Units (Limits)
			Typical (Note 6)	Limit (Note 7)	
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0V, I_o = 0A	3.5	6	mA (max)
I_{SD}	Shutdown Current	$V_{\overline{shutdown}}$ = GND	0.1	1	µA (max)
P_o	Output Power	THD = 1% (max); f = 1kHz	0.35		W
THD+N	Total Harmonic Distortion+Noise	P_o = 0.25Wrms; f = 1kHz	0.325		%
PSRR	Power Supply Rejection Ratio	V_{ripple} = 200mV sine p-p			
		f = 217Hz (Note 9)	87		dB
		f = 1kHz (Note 9)	83		
		f = 217Hz (Note 10)	80		
		f = 1kHz (Note 10)	78		
CMRR	Common-Mode Rejection Ratio	f = 217Hz	49		dB

Electrical Characteristics V_{DD} = 3V (Notes 1, 2, 8)

The following specifications apply for V_{DD} = 3V, A_V = 1, and 8Ω load unless otherwise specified. Limits apply for T_A = 25˚C. (Continued)

Note 1: All voltages are measured with respect to the ground 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 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 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 LM4894, see power derating currents for additional information.

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

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

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

Note 7: Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

Note 8: For micro SMD only, shutdown current is measured in a Normal Room Environment. Exposure to direct sunlight will increase I_{SD} by a maximum of 2µA.

Note 9: Unterminated input.

Note 10: 10Ω terminated input.

Note 11: When driving 4Ω loads from a 5V supply, the LM4894LD must be mounted to a circuit board.

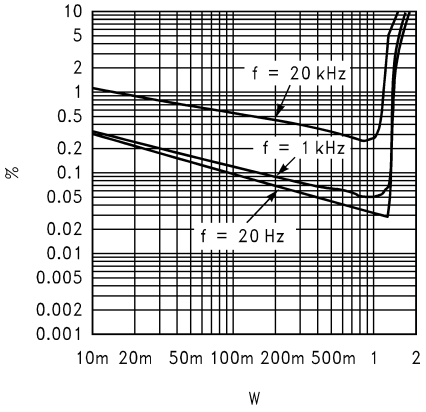
External Components Description

(*Figure 1*)

Components		Functional Description
1.	R_i	Inverting input resistance which sets the closed-loop gain in conjunction with R_f.
2.	R_f	Feedback resistance which sets the closed-loop gain in conjunction with R_i.
3.	C_S	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.
4.	C_B	Bypass pin capacitor which provides half-supply filtering. Refer to the section, **Proper Selection of External Components**, for information concerning proper placement and selection of C_B.

Typical Performance Characteristics
LD Specific Characteristics

LM4894LD
THD+N vs Output Power
V_{DD} = 5V, 4Ω R_L



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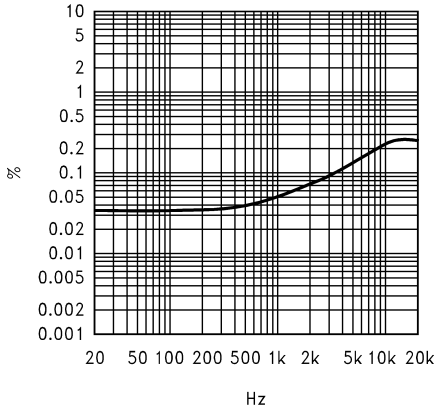
LM4894LD
THD+N vs Frequency
V_{DD} = 5V, 4Ω R_L, and Power = 1W



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Application Information (Continued)

duce peaks in excess of 1W without producing audible distortion. At this time, the designer must make sure that the power supply choice along with the output impedance does not violate the conditions explained in the **Power Dissipation** section. Once the power dissipation equations have been addressed, the required differential gain can be determined from Equation 7.

$$A_{VD} \geq \sqrt{(P_O R_L)}/(V_{IN}) = V_{orms}/V_{inrms} \quad (8)$$

$$R_f / R_i = A_{VD}$$

From Equation 7, the minimum A_{VD} is 2.83. Since the desired input impedance was 20kΩ, a ratio of 2.83:1 of R_f to R_i results in an allocation of R_i = 20kΩ for both input resistors and R_f= 60kΩ for both feedback resistors. The final design step is to address the bandwidth requirement which must be stated as a single -3dB frequency point. Five times away from a -3dB point is 0.17dB down from passband response which is better than the required ±0.25dB specified.

$$f_H = 20kHz * 5 = 100kHz$$

The high frequency pole is determined by the product of the desired frequency pole, f_H , and the differential gain, A_{VD} . With a A_{VD} = 2.83 and f_H = 100kHz, the resulting GBWP = 150kHz which is much smaller than the LM4894 GBWP of 10MHz. This figure displays that if a designer has a need to design an amplifier with a higher differential gain, the LM4894 can still be used without running into bandwidth limitations.

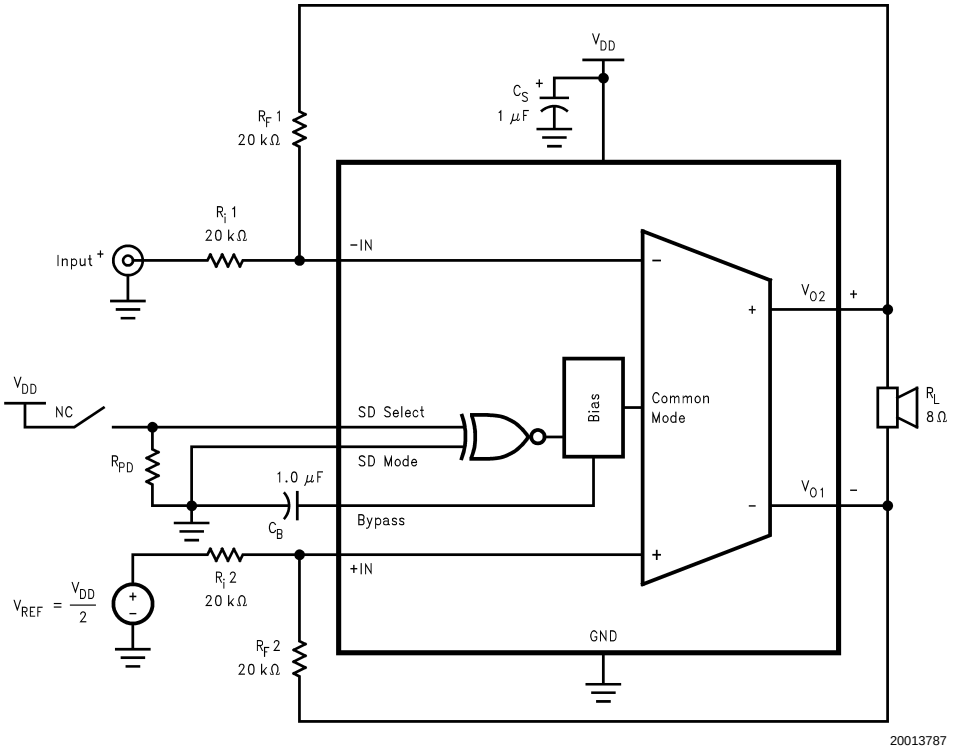

FIGURE 2. Single-Ended Input, 'Shutdown-Low' Configuration

Application Information (Continued)

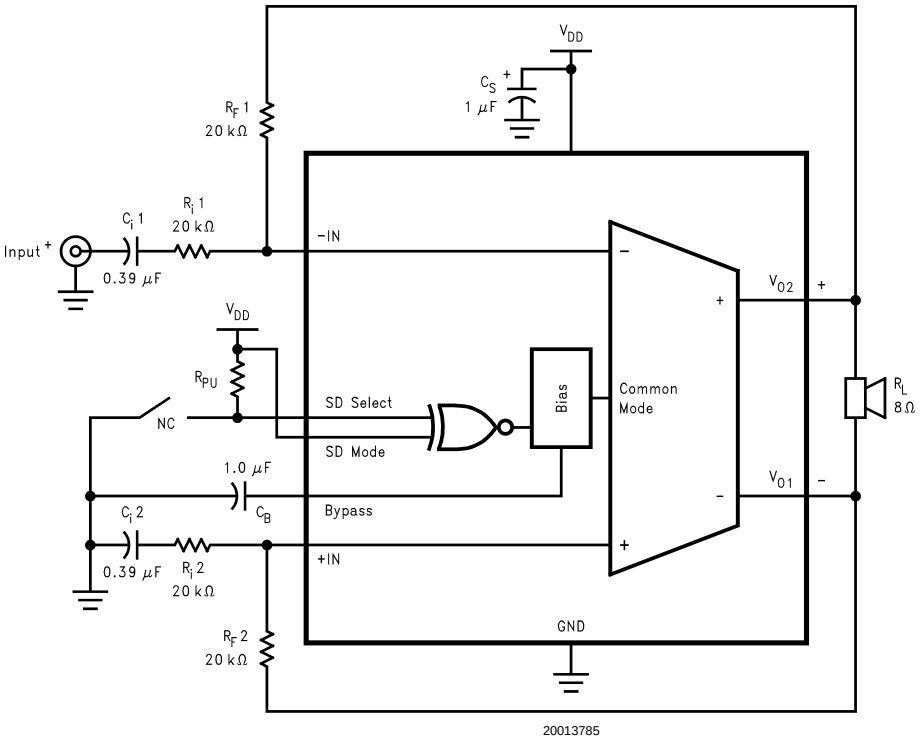

FIGURE 3. Single-Ended Input, 'Shutdown-High' Configuration

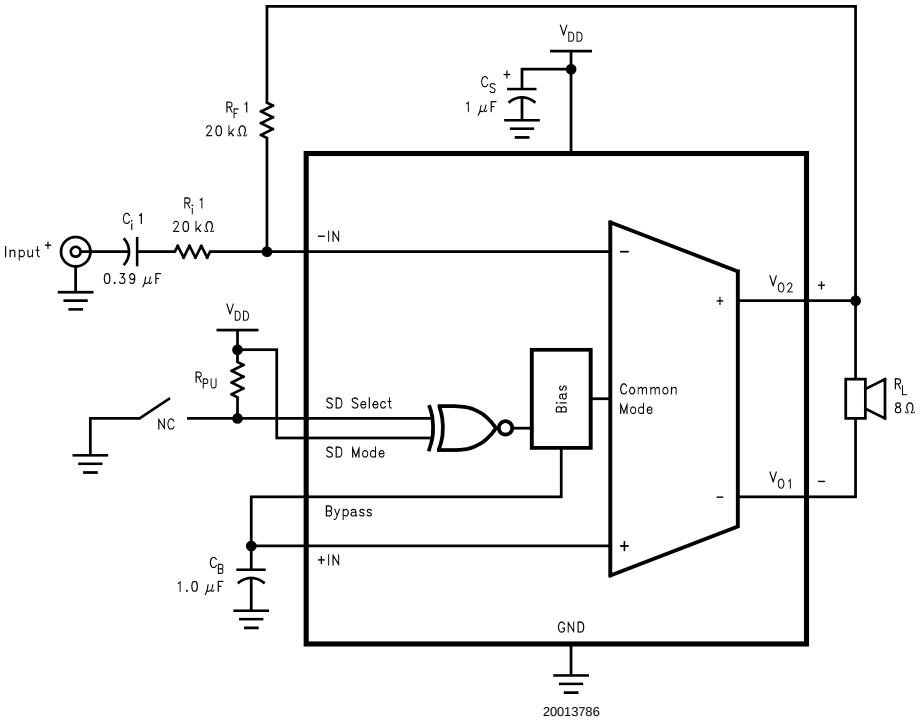

FIGURE 4. Single-Ended Input, 'Shutdown-High' Configuration