August 2000

National Semiconductor

LM4877 Boomer® Audio Power Amplifier Series
1 Watt Audio Power Amplifier in micro SMD package with Shutdown Logic Low

General Description

The LM4877 is a bridge-connected audio power amplifier capable of delivering 1 W of continuous average power to an 8Ω load with less than .2% (THD) from a 5V power supply.

Boomer audio power amplifiers were designed specifically to provide high quality output power with a minimal amount of external components. Since the LM4877 does not require output coupling capacitors or bootstrap capacitors. It is optimally suited for low-power portable applications.

The LM4877 features an externally controlled, low-power consumption shutdown mode, as well as an internal thermal shutdown protection mechanism.

The unity-gain stable LM4877 can be configured by external gain-setting resistors.

Key Specifications

- Power Output at 0.2% THD 1W (typ)
- Shutdown Current 0.01µA (typ)

Features

- micro SMD package (see App. note AN-1112)
- 5V - 2V operation
- No output coupling capacitors or bootstrap capacitors.
- Unity-gain stable
- External gain configuration capability

Applications

- Cellular Phones
- Portable Computers
- Low Voltage Audio Systems

Typical Application

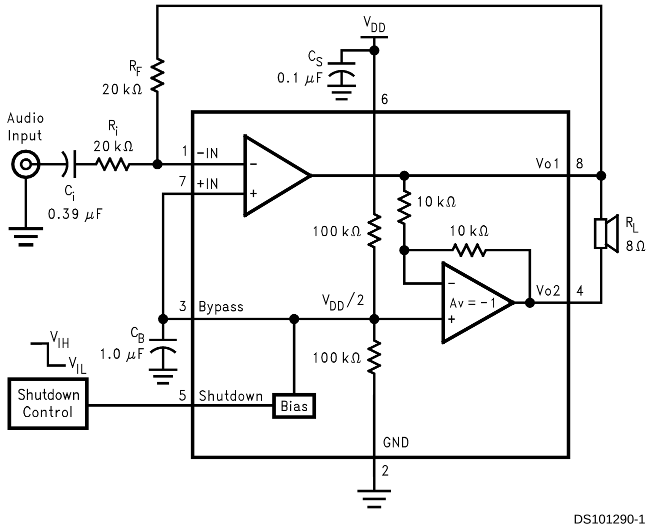
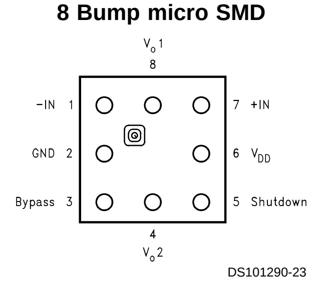


FIGURE 1. Typical Audio Amplifier Application Circuit

Connection Diagram

8 Bump micro SMD



Top View
Order Number LM4877IBP, LM4877IBPX
See NS Package Number BPA08B6B

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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)	2500V
ESD Susceptibility (Note 5)	250V
Junction Temperature	150˚C

Soldering Information

See AN-1112 ″Micro-SMD Wafers Level Chip Scale Package″.

Operating Ratings

Temperature Range	
$T_{MIN} \leq T_A \leq T_{MAX}$	−40˚C ≤ T_A ≤ 85˚C
Supply Voltage	2.0V ≤ V_{DD} ≤ 5.5V

Electrical Characteristics V_{DD} = 5V (Notes 1, 2, 9)

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

Symbol	Parameter	Conditions	LM4877		Units (Limits)
			Typical (Note 6)	Limit (Note 7)	
V_{DD}	Supply Voltage			2.0	V (min)
				5.5	V (max)
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0V, I_o = 0A	5.3	7	mA (max)
I_{SD}	Shutdown Current	V_{PIN5} = 0V	0.01	2	µA (max)
V_{OS}	Output Offset Voltage	V_{IN} = 0V	5	50	mV (max)
P_o	Output Power	THD = 0.2% (max); f = 1 kHz	1		W
THD+N	Total Harmonic Distortion+Noise	P_o = 0.25 Wrms; A_{VD} = 2; 20 Hz ≤ f ≤ 20 kHz	0.1		%
PSRR	Power Supply Rejection Ratio	V_{DD} = 4.9V to 5.1V	65		dB

Electrical Characteristics V_{DD} = 3.3V (Notes 1, 2, 9)

The following specifications apply for V_{DD} = 3.3V and 8Ω Load unless otherwise specified. Limits apply for T_A = 25˚C.

Symbol	Parameter	Conditions	LM4877		Units (Limits)
			Typical (Note 6)	Limit (Note 7)	
V_{DD}	Supply Voltage			2.0	V (min)
				5.5	V (max)
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0V, I_o = 0A	4		mA (max)
I_{SD}	Shutdown Current	V_{PIN5} = 0V	0.01		µA (max)
V_{OS}	Output Offset Voltage	V_{IN} = 0V	5		mV (max)
P_o	Output Power	THD = 1% (max); f = 1 kHz	.5	.45	W
THD+N	Total Harmonic Distortion+Noise	P_o = 0.25 Wrms; A_{VD} = 2; 20 Hz ≤ f ≤ 20 kHz	0.15		%
PSRR	Power Supply Rejection Ratio	V_{DD} = 3.2V to 3.4V	65		dB

Electrical Characteristics V_{DD} = 2.6V (Notes 1, 2, 8, 9)

The following specifications apply for V_{DD} = 2.6V and 8Ω Load unless otherwise specified. Limits apply for T_A = 25˚C.

Symbol	Parameter	Conditions	LM4877		Units (Limits)
			Typical (Note 6)	Limit (Note 7)	
V_{DD}	Supply Voltage			2.0	V (min)
				5.5	V (max)
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0V, I_o = 0A	3.4		mA (max)

Electrical Characteristics V_{DD} = 2.6V (Notes 1, 2, 8, 9)

The following specifications apply for V_{DD} = 2.6V and 8Ω Load unless otherwise specified. Limits apply for T_A = 25˚C. (Continued)

Symbol	Parameter	Conditions	LM4877		Units (Limits)
			Typical (Note 6)	Limit (Note 7)	
I_{SD}	Shutdown Current	V_{PIN5} = 0V	0.01		µA (max)
V_{OS}	Output Offset Voltage	V_{IN} = 0V	5		mV (max)
P_0	Output Power (8Ω) Output Power (4Ω)	THD = 0.3% (max); f = 1 kHz THD = 0.5% (max); f = 1 kHz	0.25 0.5		W W
THD+N	Total Harmonic Distortion+Noise	P_o = 0.25 Wrms; A_{VD} = 2; 20 Hz ≤ f ≤ 20 kHz	0.25		%
PSRR	Power Supply Rejection Ratio	V_{DD} = 2.5V to 2.7V	65		dB

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 LM4877, T_{JMAX} = 150˚C. The typical junction-to-ambient thermal resistance is 150˚C/W.

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

Note 8: Low Voltage Circuit - See Fig. 4

Note 9: Shutdown current is measured in a Normal Room Environment. Exposure to direct sunlight will increase I_{SD} by a maximum of 2µA.

Electrical Characteristics V_{DD} = 5/3.3/2.6V Shutdown Input

Symbol	Parameter	Conditions	LM4877		Units (Limits)
			Typical	Limit	
V_{IH}	Shutdown Input Voltage High			1.2	V(min)
V_{IL}	Shutdown Input Voltage Low			0.4	V(max)

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. This resistor also forms a high pass filter with C_i at $f_C = 1/(2\pi R_iC_i)$.
2.	C_i	Input coupling capacitor which blocks the DC voltage at the amplifiers input terminals. Also creates a highpass filter with R_i at $f_c = 1/(2\pi R_iC_i)$. Refer to the section, **Proper Selection of External Components**, for an explanation of how to determine the value of C_i.
3.	R_f	Feedback resistance which sets the closed-loop gain in conjunction with R_i.
4.	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.
5.	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.

Application Information (Continued)

HIGHER GAIN AUDIO AMPLIFIER

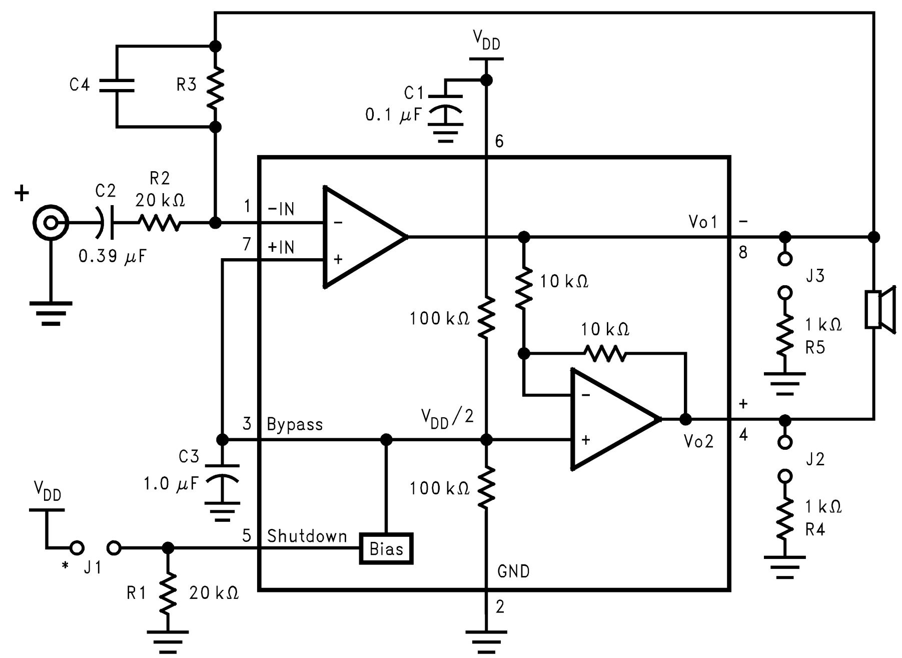


Figure 2

The LM4877 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 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_3 and C_4 will cause rolloff before 20kHz. A typical combination of feedback resistor and capacitor that will not produce audio band high frequency rolloff is R_3 = 20kΩ and C_4 = 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.

Application Information (Continued)

DIFFERENTIAL AMPLIFIER CONFIGURATION FOR LM4877

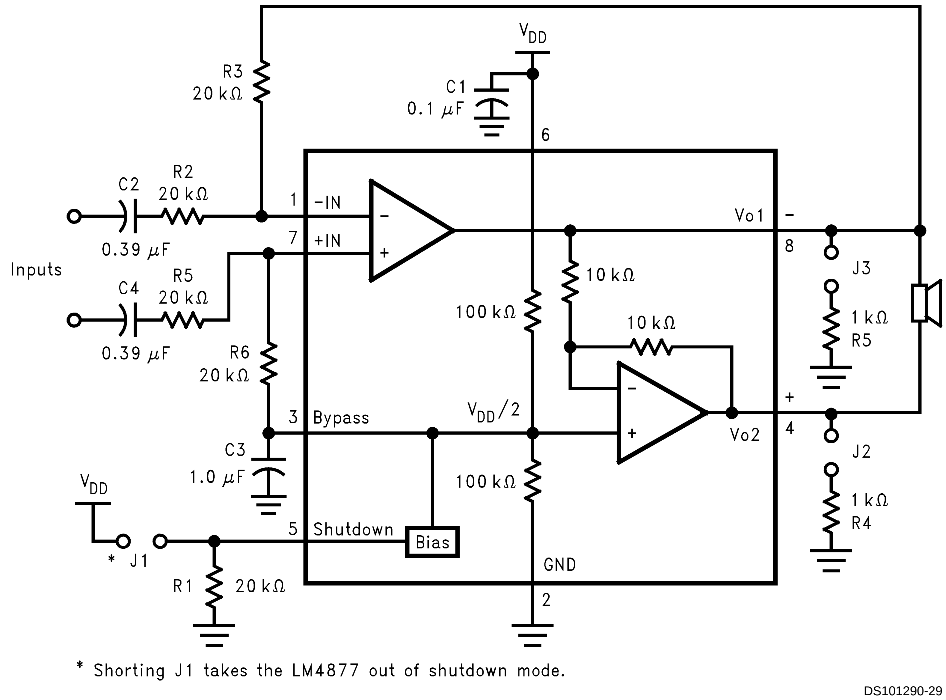


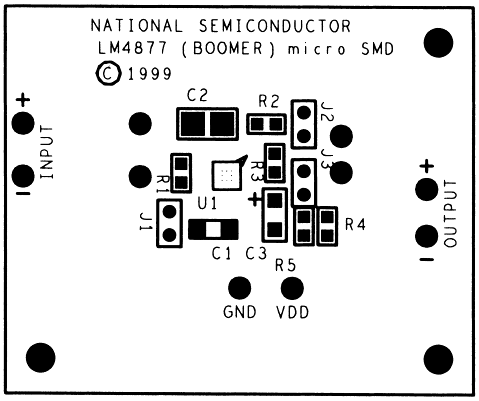
Figure 3

Mono LM4877 Reference Design Board - Assembly Part Number: 980011207-100 Revision: A Bill of Material

Item	Part Number	Part Description	Qty	Ref Designator
1	551011208-001	LM4877 Mono Reference Design Board PCB etch 001	1	
10	482911183-001	LM4877 Audio AMP micro SMD 8 Bumps	1	U1
20	151911207-001	Cer Cap 0.1uF 50V +80/-20	1	C1
21	151911207-002	Cer Cap 0.39uF 50V Z5U 20	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
31	472911207-002	Res 1K Ohm 1/10W 5	2	R4, R5,
35	210007039-002	Jumper Header Vertical Mount 2X1 0.100	3	J1, J2, J3
36	210007582-001	Jumper Shunt 2 position 0.100	3	

Application Information (Continued)

Silk Screen



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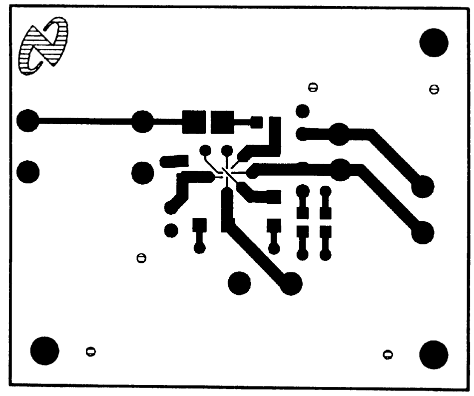
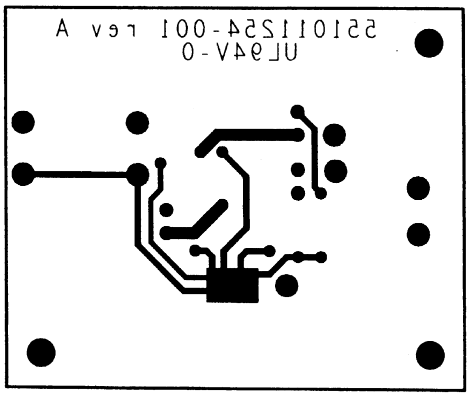
Top Layer



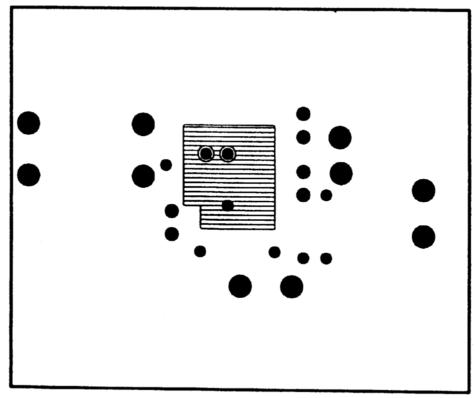
DS101290-31

Bottom Layer



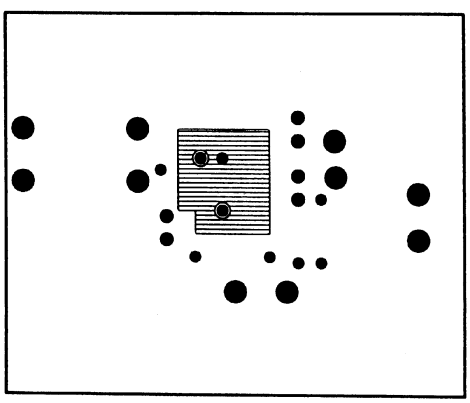
DS101290-32

Inner Layer V_{DD}



DS101290-33

Inner Layer Ground



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Application Information (Continued)

REFERENCE DESIGN BOARD and PCB LAYOUT GUIDELINES

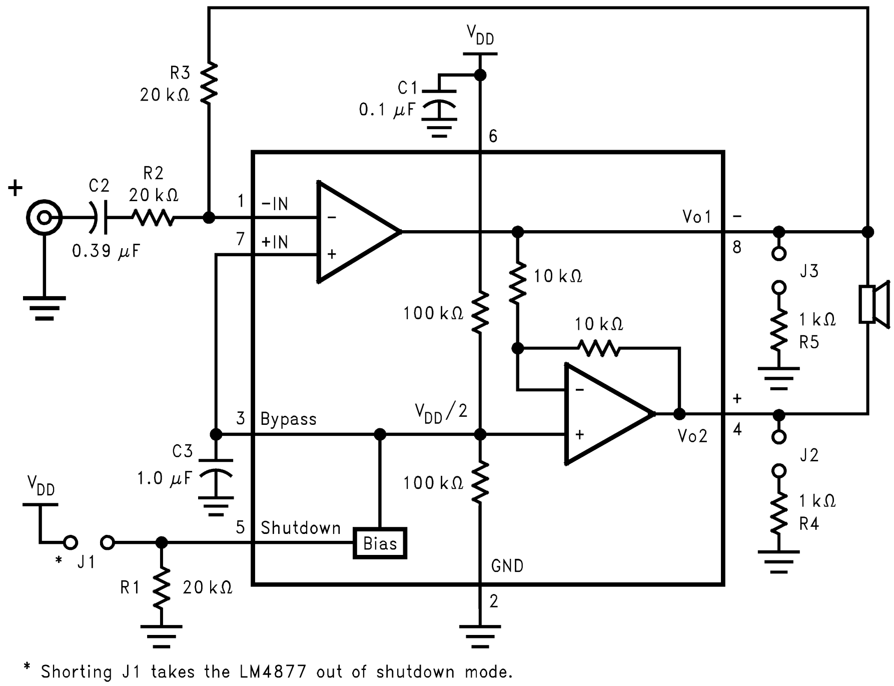

Figure 4

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 2 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 the analog components and the analog 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.