National Semiconductor

July 2002

LM4843 Boomer® Audio Power Amplifier Series
Stereo 2W Audio Power Amplifiers with DC Volume Control

General Description

The LM4843 is a monolithic integrated circuit that provides DC volume control, and stereo bridged audio power amplifiers capable of producing 2W into 4Ω (Note 1) with less than 1.0% THD or 2.2W into 3Ω (Note 2) with less than 1.0% THD.

Boomer® audio integrated circuits were designed specifically to provide high quality audio while requiring a minimum amount of external components. The LM4843 incorporates a DC volume control with stereo bridged audio power amplifiers making it optimally suited for multimedia monitors, portable radios, desktop, and portable computer applications.

The LM4843 features an externally controlled, low-power consumption shutdown mode, and both a power amplifier and headphone mute for maximum system flexibility and performance.

Note 1: When properly mounted to the circuit board, the LM4843MH will deliver 2W into 4Ω. See the Application Information section for LM4843MH usage information.

Note 2: LM4843MH that has been properly mounted to the circuit board and forced-air cooled will deliver 2.2W into 3Ω.

Key Specifications

- P_O at 1% THD+N
- into 3Ω 2.2W (typ)
- into 4Ω 2.0W (typ)
- into 8Ω 1.1W (typ)
- Shutdown current 0.7µA (typ)

Features

- Acoustically Enhanced DC Volume Control Taper
- Stereo bridged power amplifiers
- “Click and pop” suppression circuitry
- Thermal shutdown protection circuitry

Applications

- Portable and Desktop Computers
- Multimedia Monitors
- Portable Radios, PDAs, and Portable TVs

Block Diagram

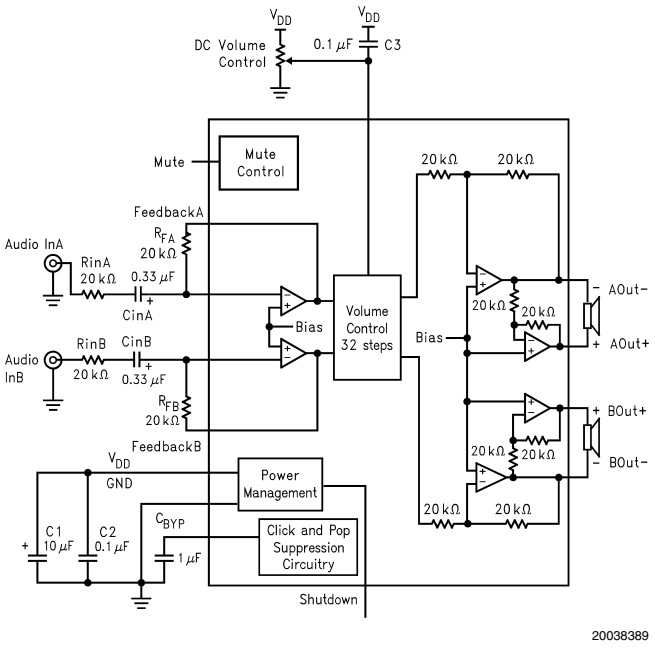

FIGURE 1. LM4843 Block Diagram

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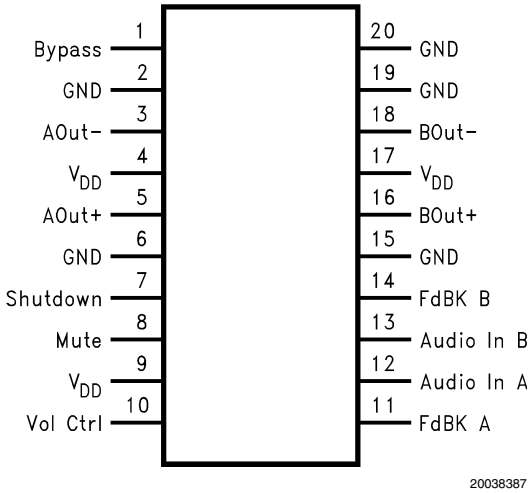
Connection Diagram

Standard LM4843MH



Top View
Order Number LM4843MH
See NS Package Number MXA20

Absolute Maximum Ratings (Note 10)

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	Internally limited
ESD Susceptibility (Note 12)	2000V
ESD Susceptibility (Note 13)	200V
Junction Temperature	150˚C
Soldering Information	
Small Outline Package	
Vapor Phase (60 sec.)	215˚C
Infrared (15 sec.)	220˚C

See AN-450 “Surface Mounting and their Effects on Product Reliability” for other methods of soldering surface mount devices.

θ_{JC} (typ)—MXA20A	2˚C/W
θ_{JA} (typ)—MXA20A (exposed DAP) (Note 4)	41˚C/W
θ_{JA} (typ)—MXA20A (exposed DAP) (Note 3)	54˚C/W
θ_{JA} (typ)—MXA20A (exposed DAP) (Note 5)	59˚C/W
θ_{JA} (typ)—MXA20A (exposed DAP) (Note 6)	93˚C/W

Operating Ratings

Temperature Range	
$T_{MIN} \le T_A \le T_{MAX}$	−40˚C ≤TA ≤ 85˚C
Supply Voltage	2.7V≤ V_{DD} ≤ 5.5V

Electrical Characteristics for Entire IC

(Notes 7, 10) The following specifications apply for V_{DD} = 5V unless otherwise noted. Limits apply for T_A = 25˚C.

Symbol	Parameter	Conditions	LM4843		Units (Limits)
			Typical (Note 14)	Limit (Note 15)	
V_{DD}	Supply Voltage			2.7	V (min)
				5.5	V (max)
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0V, I_O = 0A	15	30	mA (max)
I_{SD}	Shutdown Current	$V_{shutdown}$ = V_{DD}	0.7	2.0	µA (max)

Electrical Characteristics for Volume Attenuators

(Notes 7, 10) The following specifications apply for V_{DD} = 5V. Limits apply for T_A = 25˚C.

Symbol	Parameter	Conditions	LM4843		Units (Limits)
			Typical (Note 14)	Limit (Note 15)	
C_{RANGE}	Attenuator Range (Note 16)	Attenuation with V_{DCVol} = 5V, No Load		±0.75	dB (max)
		Attenuation with V_{DCVol} = 0V		-75	dB (min)
A_M	Mute Attenuation	V_{mute} = 5V, Bridged Mode (BM)		-78	dB (min)

Electrical Characteristics for Bridged Mode Operation

(Notes 7, 10) The following specifications apply for V_{DD} = 5V, unless otherwise noted. Limits apply for T_A = 25˚C.

Symbol	Parameter	Conditions	LM4843		Units (Limits)
			Typical (Note 14)	Limit (Note 15)	
V_{OS}	Output Offset Voltage	V_{IN} = 0V, No Load	10	±50	mV (max)
P_O	Output Power	THD + N = 1.0%; f=1kHz; R_L = 3Ω (Note 8)	2.2		W
		THD + N = 1.0%; f=1kHz; R_L = 4Ω (Note 9)	2		W
		THD = 1% (max);f = 1 kHz; R_L = 8Ω	1.1	1.0	W (min)
		THD+N = 10%;f = 1 kHz; R_L = 8Ω	1.5		W
THD+N	Total Harmonic Distortion+Noise	P_O = 1W, 20 Hz< f < 20 kHz, R_L = 8Ω, A_{VD} = 2	0.3		%
		P_O = 340 mW, R_L = 32Ω	1.0		%
PSRR	Power Supply Rejection Ratio	C_B = 1.0 µF, f = 120 Hz, V_{RIPPLE} = 200 mVrms; R_L = 8Ω	74		dB
SNR	Signal to Noise Ratio	V_{DD} = 5V, P_{OUT} = 1.1W, R_L = 8Ω, A-Wtd Filter	93		dB
X_{talk}	Channel Separation	f=1kHz, C_B = 1.0 µF	70		dB

Note 3: The θ_{JA} given is for an MXA20A package whose exposed-DAP is soldered to an exposed 2in ^{2} piece of 1 ounce printed circuit board copper.

Note 4: The θ_{JA} given is for an MXA20A package whose exposed-DAP is soldered to a 2in^2 piece of 1 ounce printed circuit board copper on a bottom side layer through 21 8mil vias.

Note 5: The θ_{JA} given is for an MXA20A package whose exposed-DAP is soldered to an exposed 1in ^{2} piece of 1 ounce printed circuit board copper.

Note 6: The θ_{JA} given is for an MXA20A package whose exposed-DAP is not soldered to any copper.

Note 7: All voltages are measured with respect to the ground pins, unless otherwise specified. All specifications are tested using the typical application as shown in *Figure 1*.

Note 8: When driving 3Ω loads from a 5V supply the LM4843MH must be mounted to the circuit board and forced-air cooled.

Note 9: When driving 4Ω loads from a 5V supply the LM4843MH must be mounted to the circuit board.

Note 10: *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. Marshall Chiu feels there are better ways to obtain 'More Wattage in the Cottage.' Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

Note 11: 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 $P_{DMAX} = (T_{JMAX} - T_A)/\theta_{JA}$. For the LM4843MH, T_{JMAX} = 150˚C, and the typical junction-to-ambient thermal resistance, when board mounted, is 80˚C/W for the MHC20 package.

Note 12: Human body model, 100 pF discharged through a 1.5 kΩ resistor.

Note 13: Machine Model, 220 pF–240 pF discharged through all pins.

Note 14: Typicals are measured at 25˚C and represent the parametric norm.

Note 15: Limits are guaranteed to National's AOQL (Average Outgoing Quality Level). Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

Note 16: Refers only to the internal Volume Attenuation steps. Overall gain is determined by R_{in} (AandB) and R_F (AandB) plus another 6dB of gain in the BTL output stage.

Typical Application

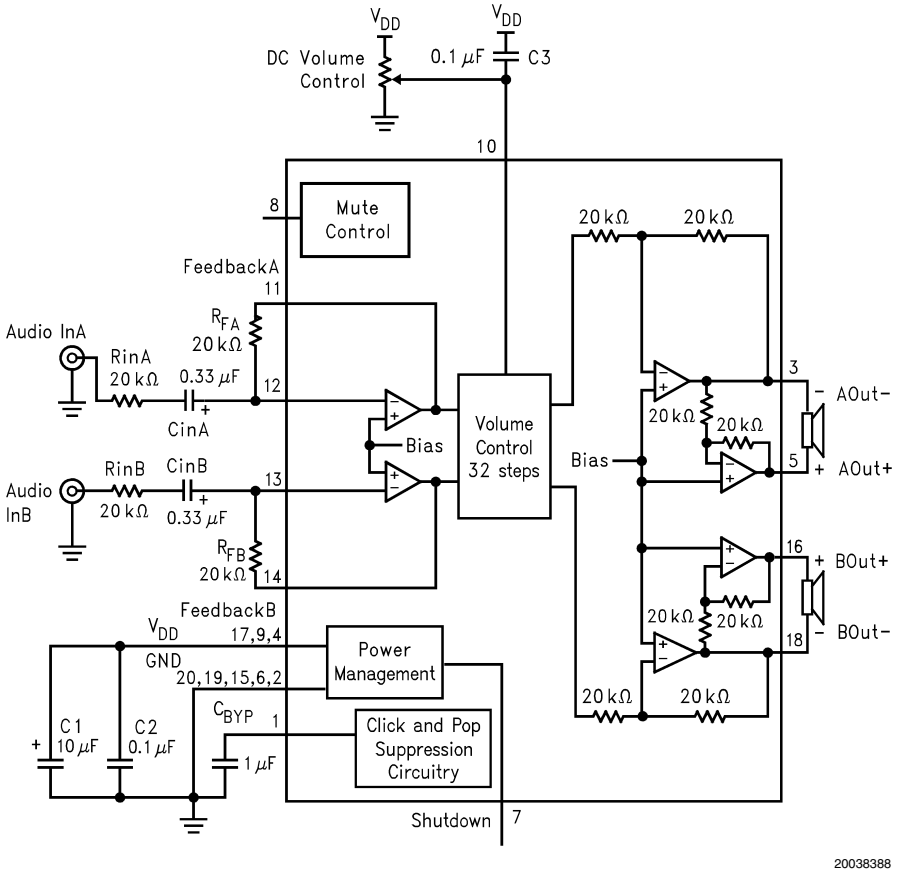
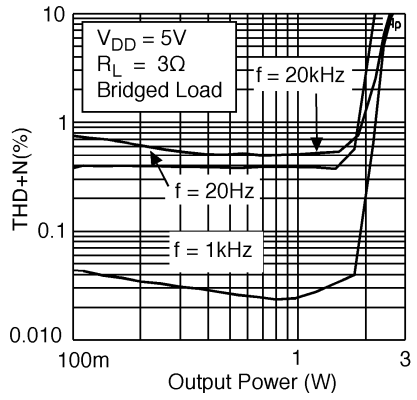


FIGURE 2. Typical Application Circuit

Typical Performance Characteristics

LM4843MH
THD+N vs Output Power



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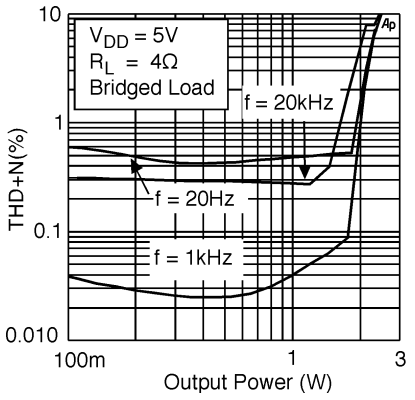
LM4843MH
THD+N vs Output Power



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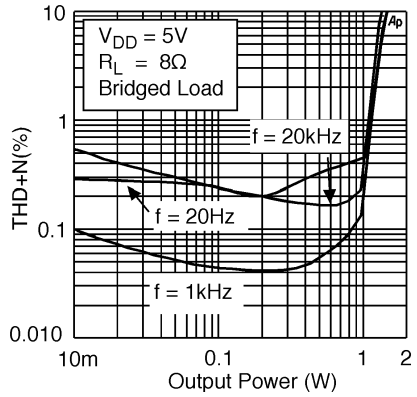
THD+N vs Output Power



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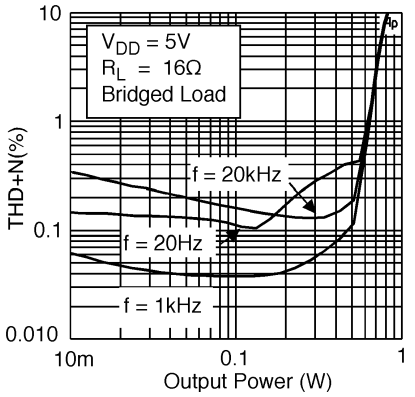
THD+N vs Output Power



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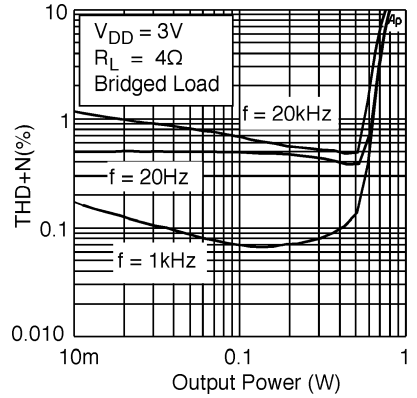
THD+N vs Output Power



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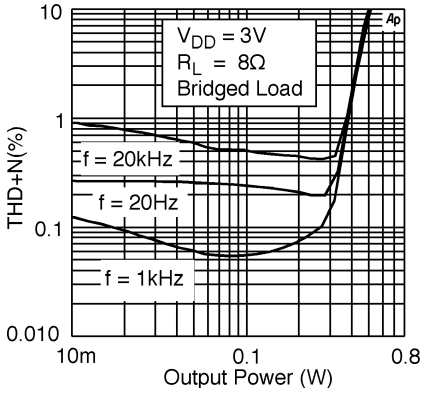
THD+N vs Output Power(Note 17)



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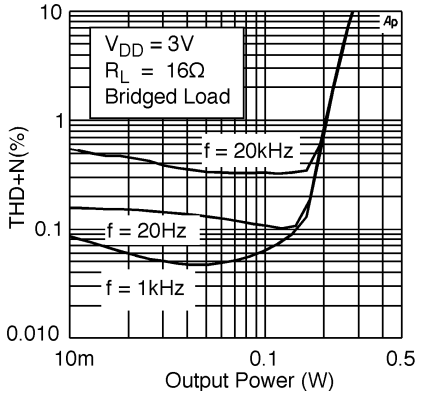
Typical Performance Characteristics (Continued)

THD+N vs Output Power



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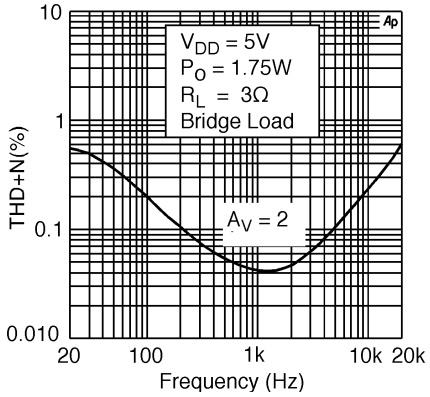
LM4843MH
THD+N vs Frequency



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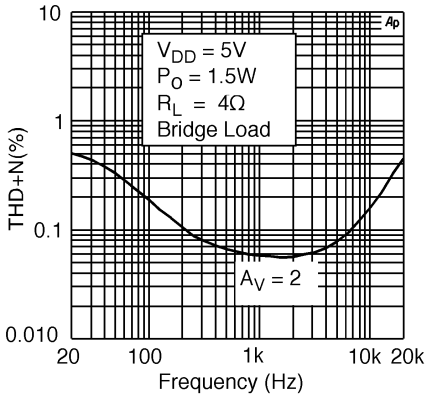
LM4843MH
THD+N vs Frequency



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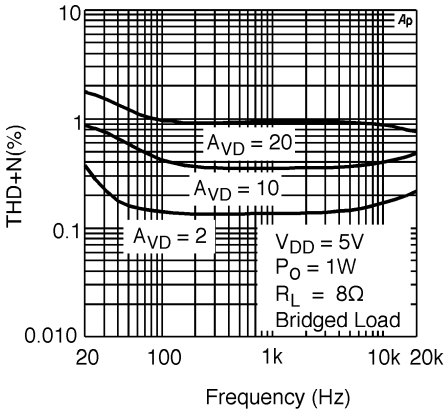
THD+N vs Frequency



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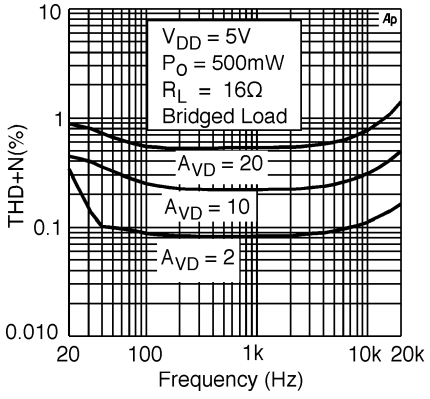
THD+N vs Frequency



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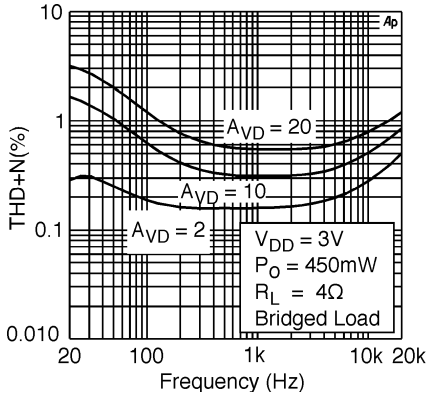
THD+N vs Frequency



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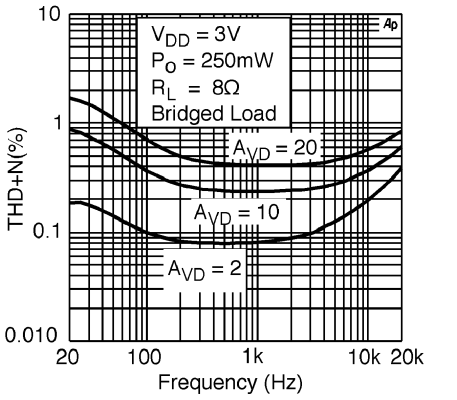
Typical Performance Characteristics (Continued)

THD+N vs Frequency



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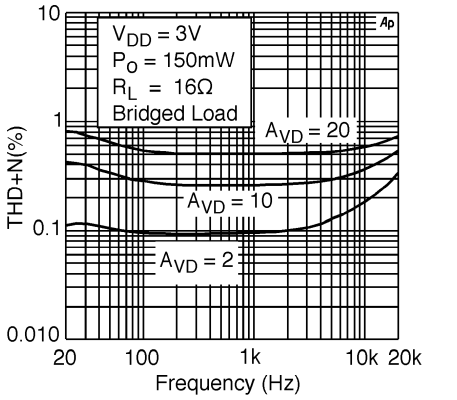
THD+N vs Frequency



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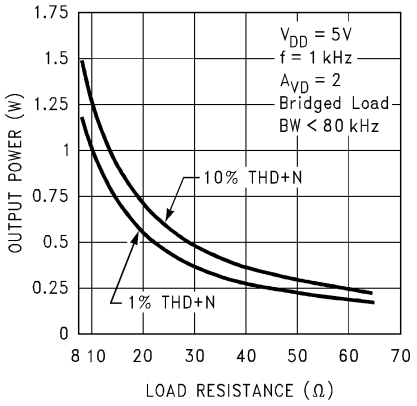
Output Power vs Load Resistance



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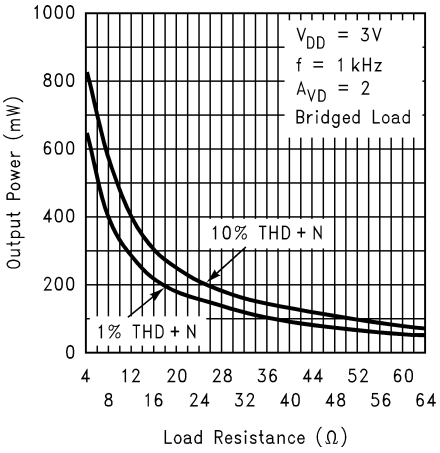
Output Power vs Load Resistance



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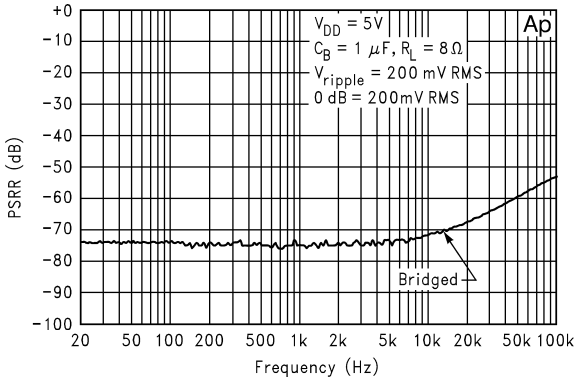
Power Supply Rejection Ratio



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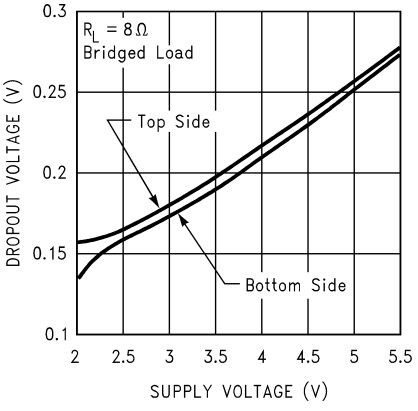
Dropout Voltage



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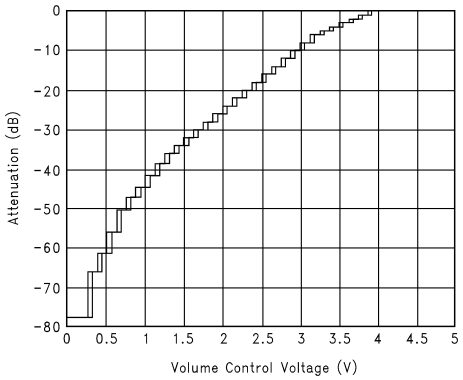
Typical Performance Characteristics (Continued)

Volume Control Characteristics



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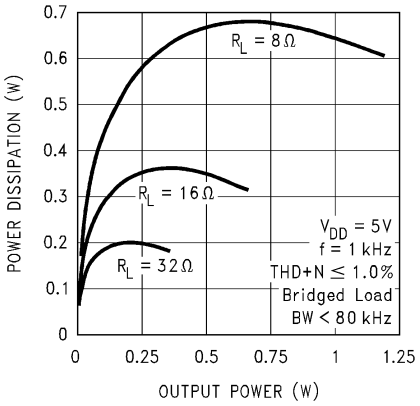
Power Dissipation vs Output Power



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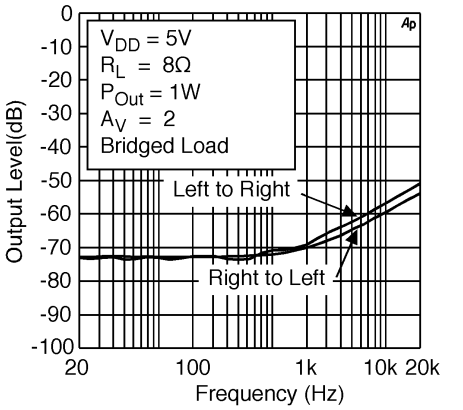
Crosstalk



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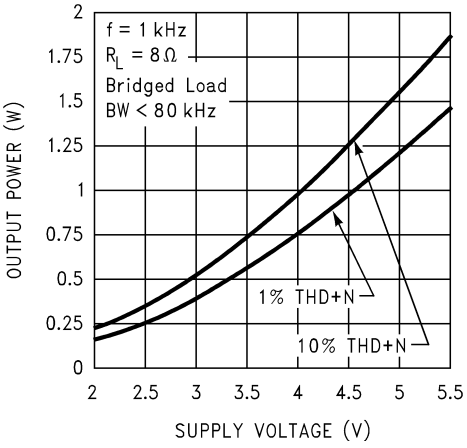
Output Power vs Supply Voltage



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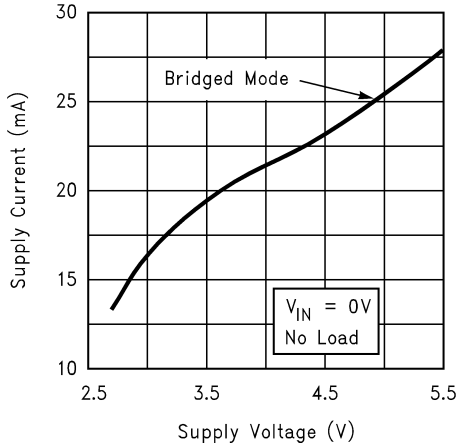
Supply Current vs Supply Voltage



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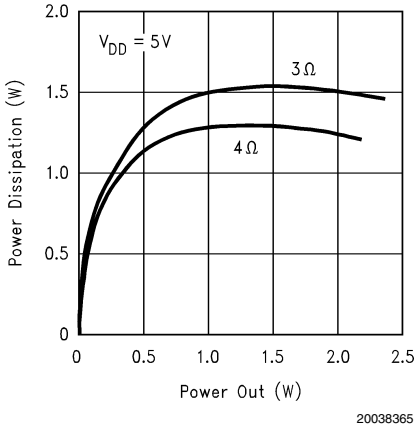
LM4843MH Power Dissipation vs Output Power



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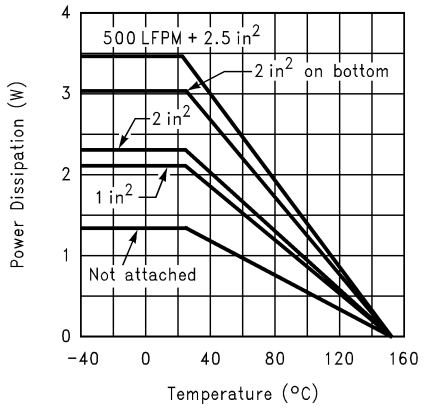
Typical Performance Characteristics (Continued)

LM4843MH (Note 17)
Power Derating Curve



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Note 17: These curves show the thermal dissipation ability of the LM4843MH at different ambient temperatures given these conditions:

500LFPM + 2in^2: The part is soldered to a 2in^2, 1 oz. copper plane with 500 linear feet per minute of forced-air flow across it.

2in^{2}on bottom: The part is soldered to a 2in^2, 1oz. copper plane that is on the bottom side of the PC board through 21 8 mil vias.

2in^2: The part is soldered to a 2in^2, 1oz. copper plane.

1in^2: The part is soldered to a 1in^2, 1oz. copper plane.

Not Attached: The part is not soldered down and is not forced-air cooled.

Application Information

EXPOSED-DAP PACKAGE PCB MOUNTING CONSIDERATIONS

The LM4843's exposed-DAP (die attach paddle) package (MH) provides a low thermal resistance between the die and the PCB to which the part is mounted and soldered. This allows rapid heat transfer from the die to the surrounding PCB copper traces, ground plane and, finally, surrounding air. The result is a low voltage audio power amplifier that produces 2.1W at ≤ 1% THD with a 4Ω load. This high power is achieved through careful consideration of necessary thermal design. Failing to optimize thermal design may compromise the LM4843's high power performance and activate unwanted, though necessary, thermal shutdown protection.

The MH package must have its exposed DAPs soldered to a grounded copper pad on the PCB. The DAP's PCB copper pad is connected to a large grounded plane of continuous unbroken copper. This plane forms a thermal mass heat sink and radiation area. Place the heat sink area on either outside plane in the case of a two-sided PCB, or on an inner layer of a board with more than two layers. Connect the DAP copper pad to the inner layer or backside copper heat sink area with 32(4x8) (MH) vias. The via diameter should be 0.012in–0.013in with a 1.27mm pitch. Ensure efficient thermal conductivity by plating-through and solder-filling the vias.

Best thermal performance is achieved with the largest practical copper heat sink area. If the heatsink and amplifier share the same PCB layer, a nominal 2.5in^2 (min) area is necessary for 5V operation with a 4Ω load. Heatsink areas not placed on the same PCB layer as the LM4843 MH package should be 5in^2 (min) for the same supply voltage and load resistance. The last two area recommendations apply for 25˚C ambient temperature. Increase the area to compensate for ambient temperatures above 25˚C. In systems using cooling fans, the LM4843MH can take advantage of forced air cooling. With an air flow rate of 450 linear-feet per minute and a 2.5in^2 exposed copper or 5.0in^2 inner layer copper plane heatsink, the LM4843MH can continuously drive a 3Ω load to full power. The junction temperature must be held below 150˚C to prevent activating the LM4843's thermal shutdown protection. The LM4843's power de-rating curve in the **Typical Performance Characteristics** shows the maximum power dissipation versus temperature. Example PCB layouts for the exposed-DAP TSSOP package are shown in the **Demonstration Board Layout** section. Further detailed and specific information concerning PCB layout and fabrication is available in National Semiconductor's AN1187.

PCB LAYOUT AND SUPPLY REGULATION CONSIDERATIONS FOR DRIVING 3Ω AND 4Ω LOADS

Power dissipated by a load is a function of the voltage swing across the load and the load's impedance. As load impedance decreases, load dissipation becomes increasingly dependent on the interconnect (PCB trace and wire) resistance between the amplifier output pins and the load's connections. Residual trace resistance causes a voltage drop, which results in power dissipated in the trace and not in the load as desired. For example, 0.1Ω trace resistance reduces the output power dissipated by a 4Ω load from 2.1W to 2.0W. This problem of decreased load dissipation is exacerbated as load impedance decreases. Therefore, to maintain the highest load dissipation and widest output voltage swing, PCB traces that connect the output pins to a load must be as wide as possible.

Poor power supply regulation adversely affects maximum output power. A poorly regulated supply's output voltage decreases with increasing load current. Reduced supply voltage causes decreased headroom, output signal clipping, and reduced output power. Even with tightly regulated supplies, trace resistance creates the same effects as poor supply regulation. Therefore, making the power supply traces as wide as possible helps maintain full output voltage swing.

BRIDGE CONFIGURATION EXPLANATION

As shown in *Figure 2*, the LM4843 output stage consists of two pairs of operational amplifiers, forming a two-channel (channel A and channel B) stereo amplifier. (Though the following discusses channel A, it applies equally to channel B.)

Figure 2 shows that the first amplifier's negative (-) output serves as the second amplifier's input. This 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 –OUTA and +OUTA and driven differentially (commonly referred to as "bridge mode"). This results in a differential gain of

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

Bridge mode amplifiers are 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 produces four times the output power when compared to a single-ended amplifier under the same conditions. This increase in attainable output power assumes that the amplifier is not current limited or that 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** section.

Another advantage of the differential bridge output is no net DC voltage across the load. This is accomplished by biasing channel A's and channel B's outputs 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. This 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 single-ended or bridged amplifier. Equation (2) states the maximum power dissipation point for a single-ended amplifier operating at a given supply voltage and driving a specified output load.

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

However, a direct consequence of the increased power delivered to the load by a bridge amplifier is higher internal power dissipation for the same conditions.

Application Information (Continued)

The LM4843 has two operational amplifiers per channel. The maximum internal power dissipation per channel operating in the bridge mode is four times that of a single-ended amplifier. From Equation (3), assuming a 5V power supply and a 4Ω load, the maximum single channel power dissipation is 1.27W or 2.54W for stereo operation.

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

The LM4843's power dissipation is twice that given by Equation (2) or Equation (3) when operating in the single-ended mode or bridge mode, respectively. Twice the maximum power dissipation point given by Equation (3) must not exceed the power dissipation given by Equation (4):

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

The LM4843's T_{JMAX} = 150˚C. In the LQ package soldered to a DAP pad that expands to a copper area of 5in^2 on a PCB, the LM4843's θ_{JA} is 20˚C/W. In the MH package soldered to a DAP pad that expands to a copper area of 2in^2 on a PCB, the LM4843MH's θ_{JA} is 41˚C/W. For the LM4843MH package, θ_{JA} = 80˚C/W. At any given ambient temperature T_A, use Equation (4) to find the maximum internal power dissipation supported by the IC packaging. Rearranging Equation (4) and substituting P_{DMAX} for P_{DMAX}' results in Equation (5). This equation gives the maximum ambient temperature that still allows maximum stereo power dissipation without violating the LM4843's maximum junction temperature.

$$T_A = T_{JMAX} - 2*P_{DMAX}\,\theta_{JA} \qquad (5)$$

For a typical application with a 5V power supply and an 4Ω load, the maximum ambient temperature that allows maximum stereo power dissipation without exceeding the maximum junction temperature is approximately 99˚C for the LQ package and 45˚C for the MH package.

$$T_{JMAX} = P_{DMAX}\,\theta_{JA} + T_A \qquad (6)$$

Equation (6) gives the maximum junction temperature T_{JMAX}. If the result violates the LM4843's 150˚C T_{JMAX}, reduce the maximum junction temperature by reducing the power supply voltage or increasing the load resistance. Further allowance should be made for increased ambient temperatures.

The above examples assume that a device is a surface mount part operating around the maximum power dissipation point. Since internal power dissipation is a function of output power, higher ambient temperatures are allowed as output power or duty cycle decreases.

If the result of Equation (2) is greater than that of Equation (3), then decrease the supply voltage, increase the load impedance, or reduce the ambient temperature. If these measures are insufficient, a heat sink can be added to reduce θ_{JA}. The heat sink can be created using additional copper area around the package, with connections to the ground pin(s), supply pin and amplifier output pins. External, solder attached MH heatsinks such as the Thermalloy 7106D can also improve power dissipation. When adding a heat sink, the θ_{JA} is the sum of θ_{JC}, θ_{CS}, and θ_{SA}. (θ_{JC} is the junction-to-case thermal impedance, θ_{CS} is the case-to-sink thermal impedance, and θ_{SA} is the sink-to-ambient thermal impedance.) Refer to the **Typical Performance Characteristics** curves for power dissipation information at lower output power levels.

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 5V regulator typically use a 10 µF in parallel with a 0.1 µF filter capacitor to stabilize the regulator's output, reduce noise on the supply line, and improve the supply's transient response. However, their presence does not eliminate the need for a local 1.0 µF tantalum bypass capacitance connected between the LM4843's supply pins and ground. Do not substitute a ceramic capacitor for the tantalum. Doing so may cause oscillation. Keep the length of leads and traces that connect capacitors between the LM4843's power supply pin and ground as short as possible. Connecting a 1µF capacitor, C_B, between the BYPASS pin and ground improves the internal bias voltage's stability and the amplifier's PSRR. The PSRR improvements increase as the bypass pin capacitor value increases. Too large a capacitor, however, increases turn-on time and can compromise the amplifier's click and pop performance. The selection of bypass capacitor values, especially C_B, depends on desired PSRR requirements, click and pop performance (as explained in the following section, **Selecting Proper External Components**), system cost, and size constraints.

SELECTING PROPER EXTERNAL COMPONENTS

Optimizing the LM4843's performance requires properly selecting external components. Though the LM4843 operates well when using external components with wide tolerances, best performance is achieved by optimizing component values.

The LM4843 is unity-gain stable, giving a 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 circuits demand input signals with greater voltage swings to achieve maximum output power. Fortunately, many signal sources such as audio CODECs have outputs of $1V_{RMS}$ ($2.83V_{P-P}$). Please refer to the **Audio Power Amplifier Design** section for more information on selecting the proper gain.

Input Capacitor Value Selection

Amplifying the lowest audio frequencies requires a high value input coupling capacitor (0.33µF in *Figure 2*), but high value capacitors 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 150 Hz. Applications using speakers with this limited frequency response reap little improvement by using a large input capacitor.

Besides effecting system cost and size, the input coupling capacitor has an affect on the LM4843'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 size.

Application Information (Continued)

Higher value capacitors need more time to reach a quiescent DC voltage (usually $V_{DD}/2$) when charged with a fixed current. The amplifier's output charges the input capacitor through the feedback resistor, R_f. Thus, pops can be minimized by selecting an input capacitor value that is no higher than necessary to meet the desired −6dB frequency.

As shown in *Figure 2*, the input resistor (R_{IR}, R_{IL} = 20k) (and the input capacitor (C_{IR}, C_{IL} = 0.33µF) produce a −6dB high pass filter cutoff frequency that is found using Equation (7).

$$f_{-6\,dB} = \frac{1}{2\pi R_{IN} C_1} \quad (7)$$

As an example when using a speaker with a low frequency limit of 150Hz, the input coupling capacitor, using Equation (7), is 0.063µF. The 0.33µF input coupling capacitor shown in *Figure 2* allows the LM4843 to drive a high efficiency, full range speaker whose response extends below 30Hz.

OPTIMIZING CLICK AND POP REDUCTION PERFORMANCE

The LM4843 contains circuitry that minimizes turn-on and shutdown transients or "clicks and pops". For this discussion, turn-on refers to either applying the power supply voltage or when the shutdown mode is deactivated. While the power supply is ramping to its final value, the LM4843's internal amplifiers are configured as unity gain buffers. An internal current source changes the voltage of the BYPASS pin in a controlled, linear manner. Ideally, the input and outputs track the voltage applied to the BYPASS pin. The gain of the internal amplifiers remains unity until the voltage on the bypass pin reaches 1/2 V_{DD} . As soon as the voltage on the bypass pin is stable, the device becomes fully operational. Although the BYPASS pin current cannot be modified, changing the size of C_B alters the device's turn-on time and the magnitude of "clicks and pops". Increasing the value of C_B reduces the magnitude of turn-on pops. However, this presents a tradeoff: as the size of C_B increases, the turn-on time increases. There is a linear relationship between the size of C_B and the turn-on time. Here are some typical turn-on times for various values of C_B:

C_B	T_{ON}
0.01µF	2ms
0.1µF	20ms
0.22µF	44ms
0.47µF	94ms
1.0µF	200ms

MICRO-POWER SHUTDOWN

The voltage applied to the SHUTDOWN pin controls the LM4843's shutdown function. Activate micro-power shutdown by applying V_{DD} to the SHUTDOWN pin. When active, the LM4843's micro-power shutdown feature turns off the amplifier's bias circuitry, reducing the supply current. The logic threshold is typically $V_{DD}/2$. The low 0.7 µA 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.

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 10kΩ 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 need for a pull up resistor.

DC VOLUME CONTROL

The LM4843 has an internal stereo volume control whose setting is a function of the DC voltage applied to the DC VOL CONTROL pin.

The LM4843 volume control consists of 31 steps that are individually selected by a variable DC voltage level on the volume control pin. The range of the steps, controlled by the DC voltage, are from 0dB - 78dB. Each attenuation step corresponds to a specific input voltage range, as shown in table 2.

To minimize the effect of noise on the volume control pin, which can affect the selected attenuation level, hysteresis has been implemented. The amount of hysteresis corresponds to half of the step width, as shown in Volume Control Characterization Graph (DS200133-40).

For highest accuracy, the voltage shown in the 'recommended voltage' column of the table is used to select a desired attenuation level. This recommended voltage is exactly halfway between the two nearest transitions to the next highest or next lowest attenuation levels.

The attenuation levels are 1dB/step from 0dB to -6dB, 2dB/step from -6dB to -36dB, 3dB/step from -36dB to -47dB, 4dB/step from -47db to -51dB, 5dB/step from -51dB to -66dB, and 12dB to the last step at -78dB.

Application Information (Continued)

Volume Control Table (Table 2)

Gain (dB)	Voltage Range (% of Vdd)			Voltage Range (Vdd = 5)			Voltage Range (Vdd = 3)		
	Low	High	Recommended	Low	High	Recommended	Low	High	Recommended
0	77.5%	100.00%	100.000%	3.875	5.000	5.000	2.325	3.000	3.000
-1	75.0%	78.5%	76.875%	3.750	3.938	3.844	2.250	2.363	2.306
-2	72.5%	76.25%	74.375%	3.625	3.813	3.719	2.175	2.288	2.231
-3	70.0%	73.75%	71.875%	3.500	3.688	3.594	2.100	2.213	2.156
-4	67.5%	71.25%	69.375%	3.375	3.563	3.469	2.025	2.138	2.081
-5	65.0%	68.75%	66.875%	3.250	3.438	3.344	1.950	2.063	2.006
-6	62.5%	66.25%	64.375%	3.125	3.313	3.219	1.875	1.988	1.931
-8	60.0%	63.75%	61.875%	3.000	3.188	3.094	1.800	1.913	1.856
-10	57.5%	61.25%	59.375%	2.875	3.063	2.969	1.725	1.838	1.781
-12	55.0%	58.75%	56.875%	2.750	2.938	2.844	1.650	1.763	1.706
-14	52.5%	56.25%	54.375%	2.625	2.813	2.719	1.575	1.688	1.631
-16	50.0%	53.75%	51.875%	2.500	2.688	2.594	1.500	1.613	1.556
-18	47.5%	51.25%	49.375%	2.375	2.563	2.469	1.425	1.538	1.481
-20	45.0%	48.75%	46.875%	2.250	2.438	2.344	1.350	1.463	1.406
-22	42.5%	46.25%	44.375%	2.125	2.313	2.219	1.275	1.388	1.331
-24	40.0%	43.75%	41.875%	2.000	2.188	2.094	1.200	1.313	1.256
-26	37.5%	41.25%	39.375%	1.875	2.063	1.969	1.125	1.238	1.181
-28	35.0%	38.75%	36.875%	1.750	1.938	1.844	1.050	1.163	1.106
-30	32.5%	36.25%	34.375%	1.625	1.813	1.719	0.975	1.088	1.031
-32	30.0%	33.75%	31.875%	1.500	1.688	1.594	0.900	1.013	0.956
-34	27.5%	31.25%	29.375%	1.375	1.563	1.469	0.825	0.937	0.881
-36	25.0%	28.75%	26.875%	1.250	1.438	1.344	0.750	0.862	0.806
-39	22.5%	26.25%	24.375%	1.125	1.313	1.219	0.675	0.787	0.731
-42	20.0%	23.75%	21.875%	1.000	1.188	1.094	0.600	0.712	0.656
-45	17.5%	21.25%	19.375%	0.875	1.063	0.969	0.525	0.637	0.581
-47	15.0%	18.75%	16.875%	0.750	0.937	0.844	0.450	0.562	0.506
-51	12.5%	16.25%	14.375%	0.625	0.812	0.719	0.375	0.487	0.431
-56	10.0%	13.75%	11.875%	0.500	0.687	0.594	0.300	0.412	0.356
-61	7.5%	11.25%	9.375%	0.375	0.562	0.469	0.225	0.337	0.281
-66	5.0%	8.75%	6.875%	0.250	0.437	0.344	0.150	0.262	0.206
-78	0.0%	6.25%	0.000%	0.000	0.312	0.000	0.000	0.187	0.000

Application Information (Continued)

AUDIO POWER AMPLIFIER DESIGN

Audio Amplifier Design: Driving 1W into an 8Ω Load

The following are the desired operational parameters:

Power Output:	1 W_{RMS}
Load Impedance:	8Ω
Input Level:	1 V_{RMS}
Input Impedance:	20 kΩ
Bandwidth:	100 Hz–20 kHz ± 0.25 dB

The design begins by specifying the minimum supply voltage necessary to obtain the specified output power. One way to find the minimum supply voltage is to use the Output Power vs Supply Voltage curve in the **Typical Performance Characteristics** section. Another way, using Equation (10), is to calculate the peak output voltage necessary to achieve the desired output power for a given load impedance. To account for the amplifier's dropout voltage, two additional voltages, based on the Dropout Voltage vs Supply Voltage in the **Typical Performance Characteristics** curves, must be added to the result obtained by Equation (10). The result is Equation (11).

$$V_{outpeak} = \sqrt{(2R_L P_O)} \quad (8)$$

$$V_{DD} \geq (V_{OUTPEAK} + (V_{OD_{TOP}} + V_{OD_{BOT}})) \quad (9)$$

The Output Power vs Supply Voltage graph for an 8Ω load indicates a minimum supply voltage of 4.6V. This is easily met by the commonly used 5V supply voltage. The additional voltage creates the benefit of headroom, allowing the LM4843 to produce peak output power in excess of 1W without clipping or other audible distortion. The choice of supply voltage must also not create a situation that violates of maximum power dissipation as explained above in the **Power Dissipation** section.

After satisfying the LM4843's power dissipation requirements, the minimum differential gain needed to achieve 1W dissipation in an 8Ω load is found using Equation (12).

$$A_{VD} \geq \sqrt{(P_O R_L)}/(V_{IN}) = V_{orms}/V_{inrms} \quad (10)$$

Thus, a minimum overall gain of 2.83 allows the LM4843's to reach full output swing and maintain low noise and THD+N performance.

The last step in this design example is setting the amplifier's –6dB frequency bandwidth. To achieve the desired ±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 within the ±0.25dB desired limit. The results are an

$$f_L = 100Hz/5 = 20Hz \quad (11)$$

and an

$$f_H = 20kHz \times 5 = 100kHz \quad (12)$$

As mentioned in the **Selecting Proper External Components** section, R_i (Right & Left) and C_i (Right & Left) create a highpass filter that sets the amplifier's lower bandpass frequency limit. Find the input coupling capacitor's value using Equation (14).

$$C_i \geq 1/(2\pi R_i f_L) \quad (13)$$

The result is

$$1/(2\pi * 20k\Omega * 20Hz) = 0.397\mu F \quad (14)$$

Use a 0.39µF capacitor, the closest standard value.

The product of the desired high frequency cutoff (100kHz in this example) and the differential gain A_{VD}, determines the upper passband response limit. With A_{VD} = 3 and f_H = 100kHz, the closed-loop gain bandwidth product (GBWP) is 300kHz. This is less than the LM4843's 3.5MHz GBWP. With this margin, the amplifier can be used in designs that require more differential gain while avoiding performance,restricting bandwidth limitations.

Recommended Printed Circuit Board Layout

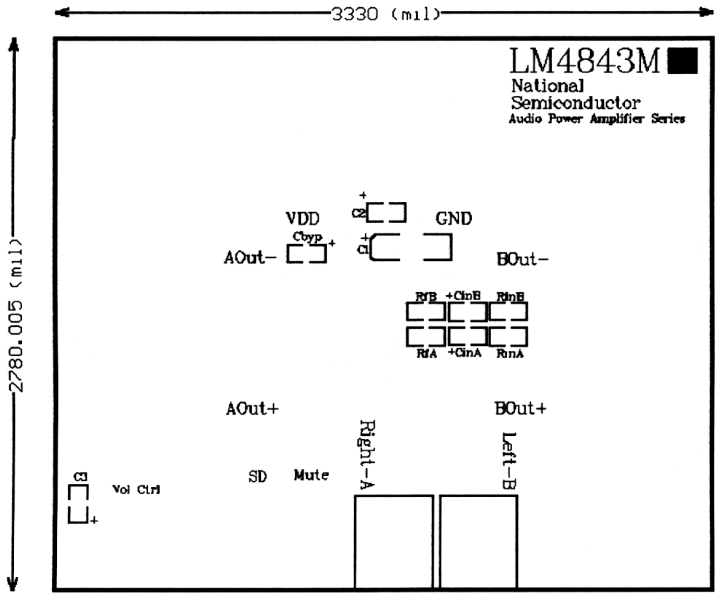
Figure (6) through (10) show the recommended four-layer PC board layout that is optimized for the 24-pin LQ-packaged LM4843 and associated external components. This circuit is designed for use with an external 5V supply and 4Ω speakers.

This circuit board is easy to use. Apply 5V and ground to the board's V_{DD} and GND pads, respectively. Connect 4Ω speakers between the board's –OUTA and +OUTA and OUTB and +OUTB pads.

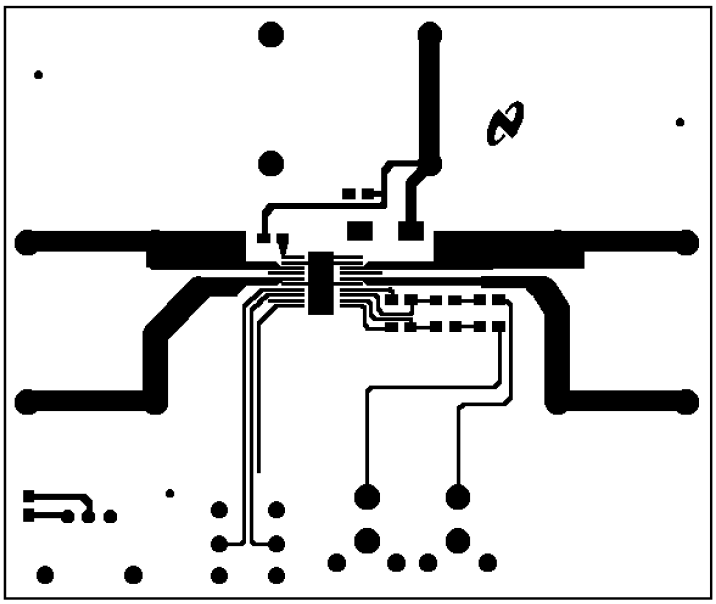
Analog Audio LM4843 MSOP Eval Board
Assembly Part Number: 980011373-100
Revision: A
Bill of Material

Item	Part Number	Part Description	Qty	Ref Designator	Remark
1	551011373-001	LM4843 Eval Board PCB etch 001	1		
10	482911373-001	LM4843 MSOP	1		
25	152911368-001	Tant Cap 0.1µF 10V 10% Size = A 3216	2	C2, C3	
26	152911368-002	Tant Cap 0.33µF 10V 10% Size = A 3216	3	$C_{in}A$, $C_{in}B$	
27	152911368-003	Tant Cap 1µF 16V 10% Size = A 3216	1	C_{BYP}	
28	152911368-004	Tant Cap 10µF 10V 10% Size = C 6032	1	C1	
31	472911368-002	Res 20K Ohm 1/8W 1% 1206	4		$R_{in}A$, $R_{in}B$, R_{FA}, R_{FB}
40	131911368-001	Stereo Headphone Jack W/ Switch	1		Mouser #
41	131911368-002	Slide Switch	2	SD, Mute	Mouser # 10SP003
42	131911368-003	Potentiometer	1	Volume Control	Mouser # 317-2090-100K
43	131911368-004	RCA Jack	2	In A, In B	Mouser # 16PJ097
44	131911368-005	Banana Jack, Black	3	A_{out-}, B_{out-}, GND	Mouser # ME164-6219
45	131911368-006	Banana Jack, Red	3	A_{out+}, B_{ou+}, V_{DD}	Mouser # ME164-6218

LM4843MH Demo Boards

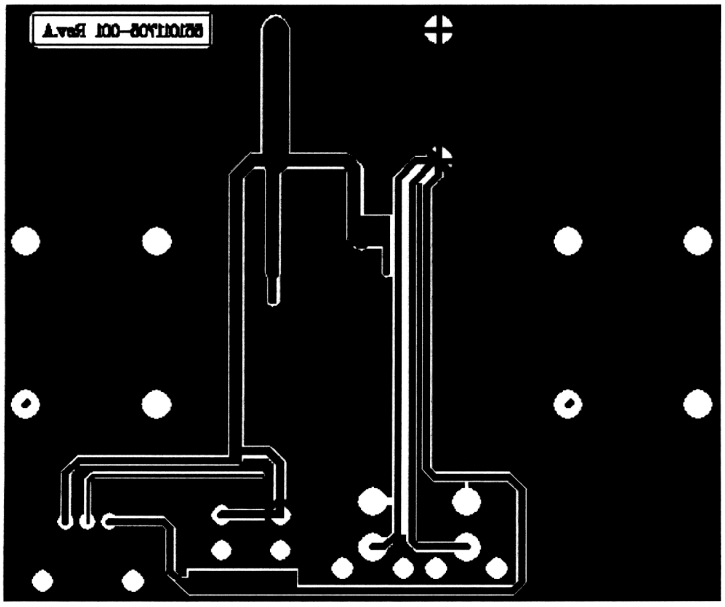


Top Layer SilkScreen



Top Layer TSSOP

LM4843MH Demo Boards (Continued)



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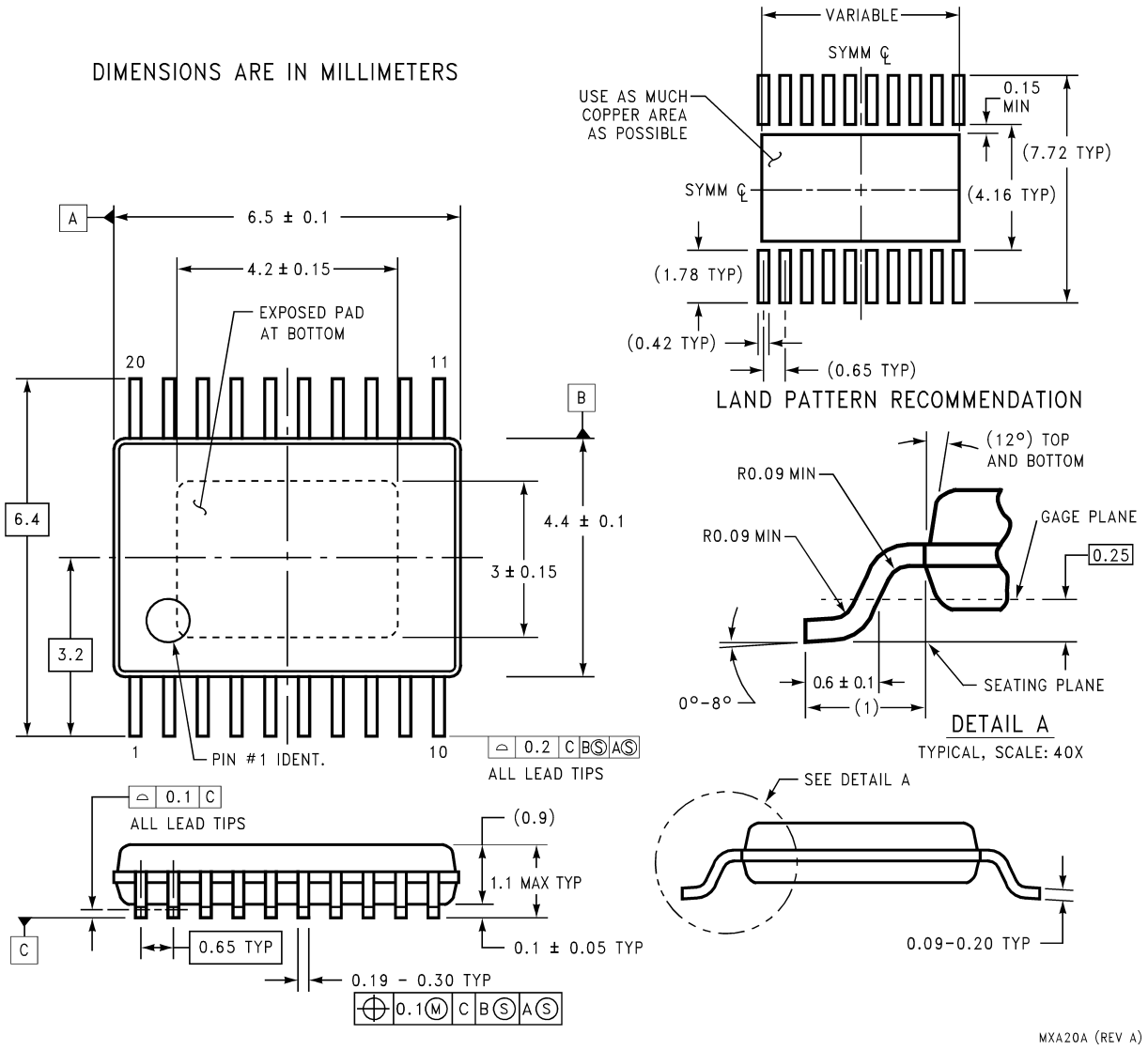
Bottom Layer (2) LM4843MH

Physical Dimensions inches (millimeters) unless otherwise noted



Exposed-DAP TSSOP Package
Order Number LM4843MH
NS Package Number MXA20A for Exposed-DAP TSSOP

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