National Semiconductor

LM48580

Boomer® Audio Power Amplifier Series

February 23, 2010

High Efficiency Class H, High Voltage, Haptic Piezo Actuator / Ceramic Speaker Driver

LM48580 High Efficiency Class H, High Voltage, Haptic Piezo Actuator / Ceramic Speaker Driver

General Description

The LM48580 is a fully differential, high voltage driver for piezo actuators and ceramic speakers for portable multi-media devices. Part of National's Powerwise product line, the LM48580's Class H architecture offers significant power savings compared to traditional Class AB amplifiers. The device provides $30V_{P-P}$ output drive while consuming just 15mW of quiescent power.

The LM48580 is a single supply driver with an integrated boost converter which allows the device to deliver $30V_{P-P}$ from a single 3.6V supply.

The LM48580 has three pin-programmable gain settings and a low power Shutdown mode that reduces quiescent current consumption to 0.1µA. The LM48580 is available in an ultra-small 12-bump micro SMD package (1.46mm x 1.97mm).

Key Specifications

- Output Voltage at V_{DD} = 3.6V
  R_L = 6µF+10Ω, THD+N ≤ 1% — $30V_{P-P}$ (typ)
- Quiescent Power Supply current at 3.6V — 2.7mA (typ)
- Power Dissipation at $25V_{P-P}$ — 800mW (typ)
- Shutdown current — 0.1µA (typ)

Features

- Class H Driver
- Integrated Boost Converter
- Bridge-tied Load Output
- Differential Input
- Three Pin-Programmable Gains
- Low Supply Current
- Minimum external components
- Micro-power shutdown
- Thermal overload protection
- Available in space-saving 12-bump microSMD package

Applications

- Touch screen Smart Phones
- Tablet PCs
- Portable Electronic Devices
- MP3 Players

Typical Application

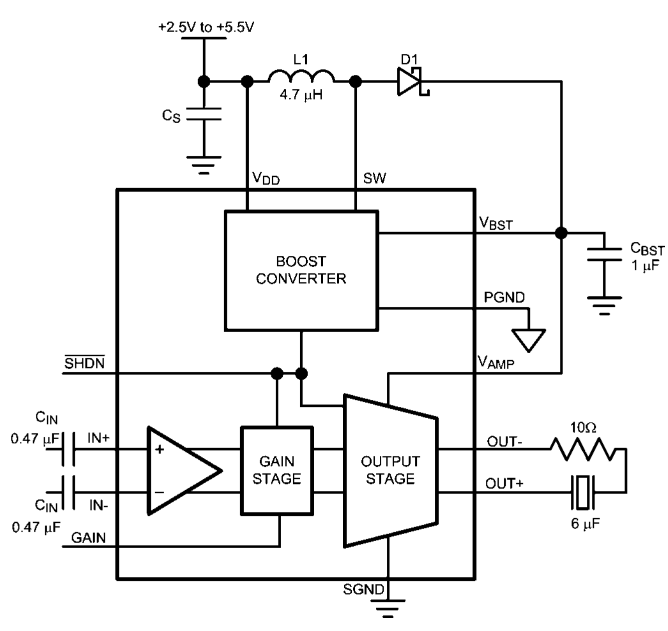
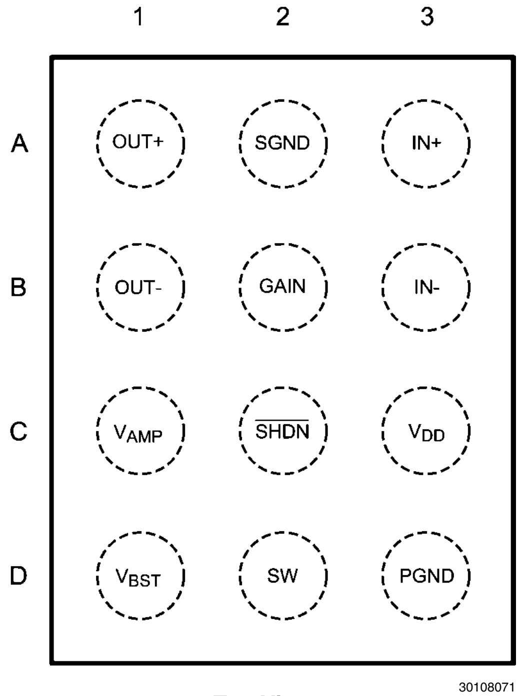


FIGURE 1. Typical Application Circuit

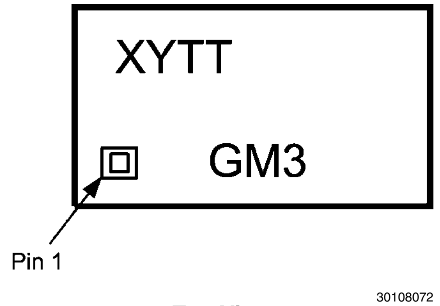
Connection Diagrams

TL Package
1.46mm x 1.97mm x 0.6mm



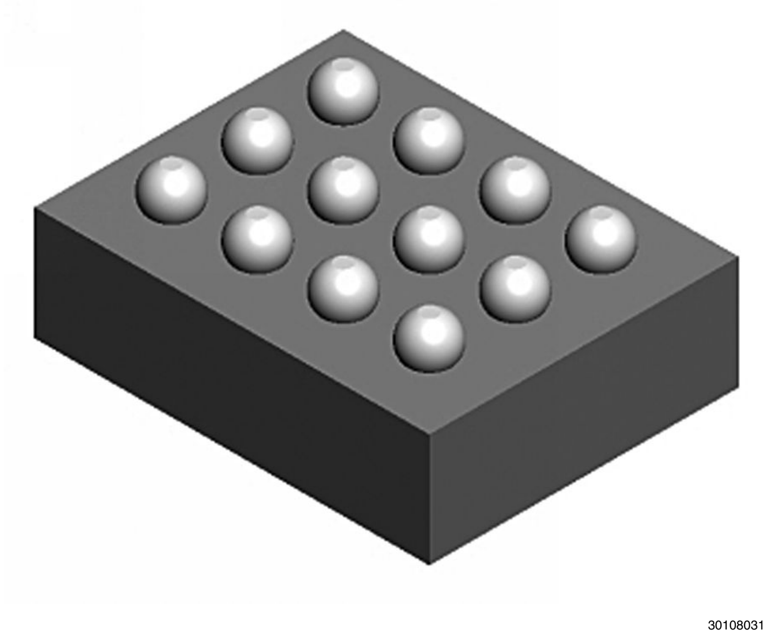
Top View
Order Number LM48580TL
See NS Package Number TLA12Z1A

12–Bump micro SMD Marking



Top View
XY = Date code
TT = Die traceability
G = Boomer Family
M3 = LM48580TL

TLA12 Package View (Bumps Up)



Ordering Information

Ordering Information Table

Order Number	Package	Package Drawing Number	Transport Media	MSL Level	Green Status
LM48580TL	12 Bump µSMD	TLA12Z1A	250 units on tape and reel	1	RoHS & no Sb/Br
LM48580TLX	12 Bump µSMD	TLA12Z1A	3000 units on tape and reel	1	RoHS & no Sb/Br

Pin Descriptions

TABLE 1. Bump Descriptions

Bump	Name	Description
A1	OUT+	Amplifier Non-Inverting Output
A2	SGND	Amplifier Ground
A3	IN+	Amplifier Non-Inverting Input
B1	OUT-	Amplifier Inverting Output
B2	GAIN	Gain Select: GAIN = float: A_V = 18dB GAIN = GND: A_V = 24dB GAIN = V_{DD}: A_V = 30dB
B3	IN-	Amplifier Inverting Input
C1	V_{AMP}	Amplifier Supply Voltage. Connect to V_{BST}
C2	$\overline{SHDN}$	Active Low Shutdown. Drive $\overline{SHDN}$ low to disable device. Connect $\overline{SHDN}$ to V_{DD} for normal operation.
C3	V_{DD}	Power Supply
D1	V_{BST}	Boost Converter Output
D2	SW	Boost Converter Switching Node
D3	PGND	Boost Converter Ground

Absolute Maximum Ratings (Note 1, Note 2)

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

Supply Voltage (Note 1)	6V
SW Voltage	25V
VBST Voltage	21V
V_{AMP}	17V
Input Voltage	−0.3V to V_{DD} + 0.3V
Power Dissipation (Note 3)	Internally limited
ESD Rating, Human Body Model (Note 4)	2kV
ESD Rating, Machine Model (Note 5)	150V
ESD Rating, Charge Device Model (Note 6)	750V
Storage Temperature	−65°C to + 150°C
Junction Temperature	150°C
Thermal Resistance	
θ_{JA} (TLA12Z1A)	64 °C/W

Soldering Information

See AN-1112 "Micro SMD Wafer Level Chip Scale Package."

Operating Ratings

Temperature Range	
$T_{MIN} \le T_A \le T_{MAX}$ (Note 10)	$-40°C \le T_A \le +85°C$
Supply Voltage	
V_{DD}	$2.5V \le V_{DD} \le 5.5V$

Electrical Characteristics V_{DD} = 3.6V (Note 1, Note 2)

The following specifications apply for R_L = 6μF + 10Ω, C_{BST} = 1μF, C_{IN} = 0.47μF, A_V = 24dB unless otherwise specified. Limits apply for T_A = 25°C.

Symbol	Parameter	Conditions	LM48580 Min (Note 8)	LM48580 Typ (Note 7)	Max (Note 8)	Units (Limits)
V_{DD}	Supply Voltage Range		2.5		5.5	V
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0V, R_L = ∞				
		V_{DD} = 3.6V		2.7	4	mA
		V_{DD} = 3V		3		mA
P_D	Power Consumption	V_{OUT} = 25_{P-P}, f = 200Hz				
		V_{DD} = 3.6V		800		mW
		V_{DD} = 3V		830		mW
I_{SD}	Shutdown Current	Shutdown Enabled		0.5	2	μA
T_{WU}	Wake-up Time	From Shutdown	1	1.4	1.6	ms
V_{OS}	Differential Output Offset Voltage	V_{DD} = 3.6V		63	360	mV
A_V	Gain	GAIN = FLOAT GAIN = GND GAIN = V_{DD}	17.5 23.5 29.5	18 24 30	18.5 24.5 30.5	dB dB dB
R_{IN}	Input Resistance		46	52	58	kΩ
R_{IN}	Gain Input Resistance	to GND to V_{DD}			575 131	kΩ kΩ
V_{IN}	Maximum Input Voltage Range	A_V = 18dB			3	V_{P-P}
V_{OUT}	Output Voltage	f = 200Hz, THD+N = 1% V_{DD} = 3.6V V_{DD} = 3V	 25	 30.5 30.5		 V_{P-P} V_{P-P}
		f = 2kHz, THD+N = 5% V_{DD} = 3.6V V_{DD} = 3V		 11 8.5		 V_{P-P} V_{P-P}
THD+N	Total Harmonic Distortion + Noise	V_{OUT} = $25V_{P-P}$, f = 200Hz		0.16		%
PSRR	Power Supply Rejection Ratio (Figure TBD)	V_{DD} = 3.6V + $200mV_{p-p}$ sine, Inputs AC GND				
		f_{RIPPLE} = 217Hz, f_{RIPPLE} = 1kHz		75 71		dB dB
CMRR	Common Mode Rejection Ratio (Figure TBD)	V_{CM} = $200mV_{P-P}$ sine				
		f_{RIPPLE} = 217Hz f_{RIPPLE} = 1kHz		56 55		dB dB

Symbol	Parameter	Conditions	LM48580			Units (Limits)
			Min (Note 8)	Typ (Note 7)	Max (Note 8)	
f_{SW}	Boost Converter Switching Frequency			2.1		MHz
I_{LIMIT}	Boost Converter Current Limit				1100	mA
V_{IH}	Logic High Input Threshold	$\overline{SHDN}$	1.2			V
V_{IL}	Logic Low Input Threshold	$\overline{SHDN}$			0.45	V
I_{IN}	Input Leakage Current	$\overline{SHDN}$		0.1	1	μA

Note 1: "*Absolute Maximum Ratings*" indicate limits beyond which damage to the device may occur, including inoperability and degradation of device reliability and/or performance. Functional operation of the device and/or non-degradation at the *Absolute Maximum Ratings* or other conditions beyond those indicated in the *Recommended Operating Conditions* is not implied. The *Recommended Operating Conditions* indicate conditions at which the device is functional and the device should not be operated beyond such conditions. All voltages are measured with respect to the ground pin, unless otherwise specified.

Note 2: The *Electrical Characteristics* tables list guaranteed specifications under the listed *Recommended Operating Conditions* except as otherwise modified or specified by the *Electrical Characteristics Conditions* and/or Notes. Typical specifications are estimations only and are not guaranteed.

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 given in *Absolute Maximum Ratings*, whichever is lower.

Note 4: Human body model, applicable std. JESD22-A114C.

Note 5: Machine model, applicable std. JESD22-A115-A.

Note 6: Charge device model, applicable std. JESD22-C101-C.

Note 7: Typical values represent most likely parametric norms at T_A = +25ºC, and at the *Recommended Operation Conditions* at the time of product characterization and are not guaranteed.

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

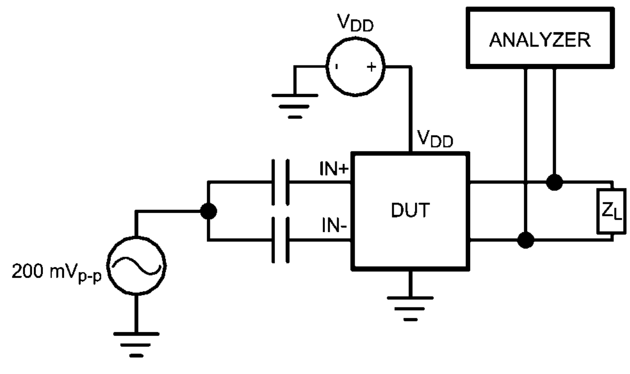


FIGURE 2. PSRR Test Circuit

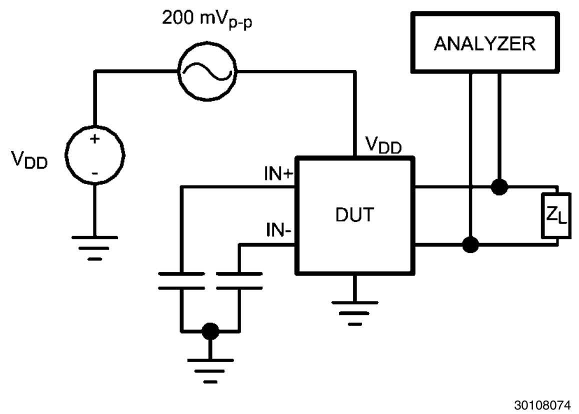
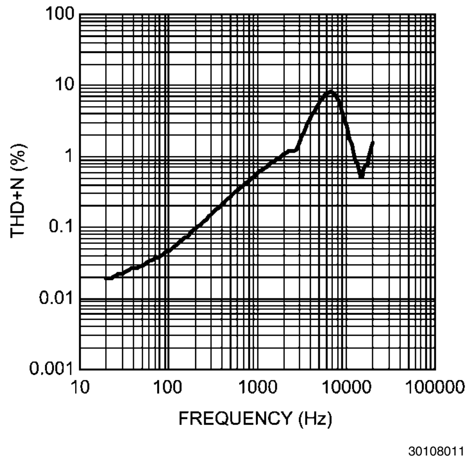


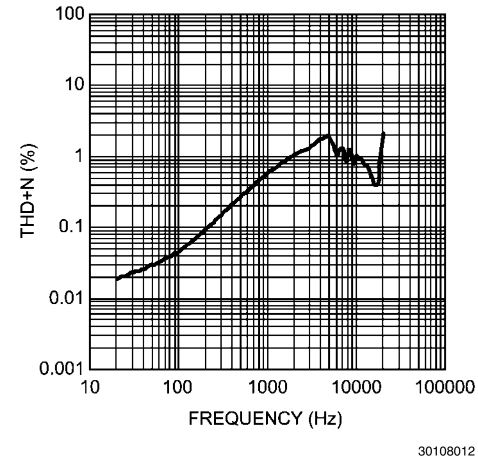
FIGURE 3. CMRR Test Circuit

Typical Performance Characteristics

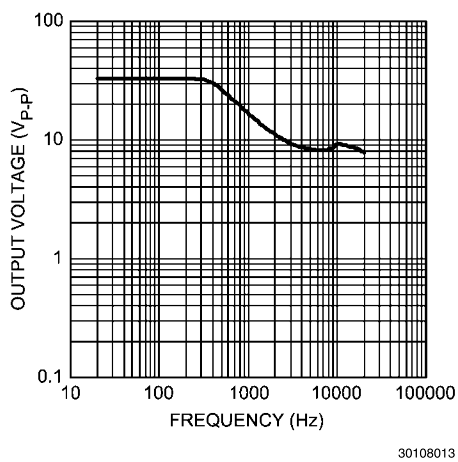
THD+N vs Frequency
V_{DD} = 3.6V, V_{OUT} = $9V_{P-P}$
R_L = 6μF + 10Ω



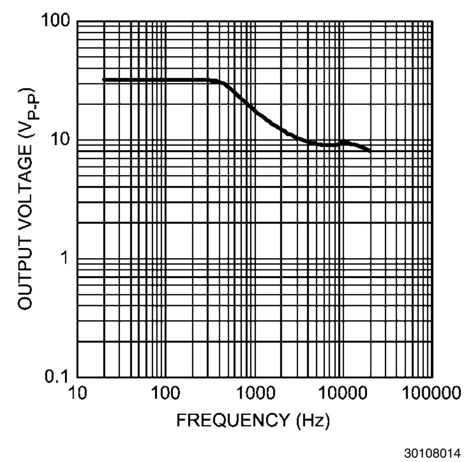
THD+N vs Frequency
V_{DD} = 4.2V, V_{OUT} = $10V_{P-P}$
R_L = 6μF + 10Ω



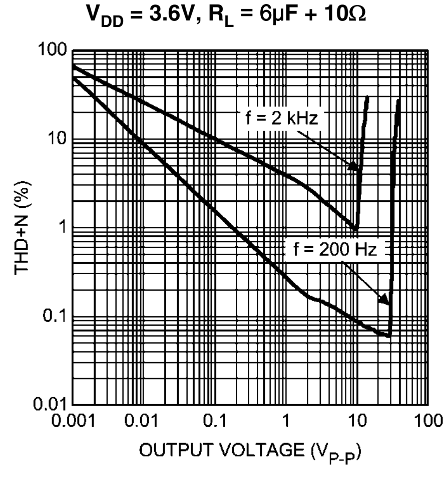
Output Voltage vs Frequency
V_{DD} = 3.6V, THD+N = 5%
R_L = 6μF + 10Ω



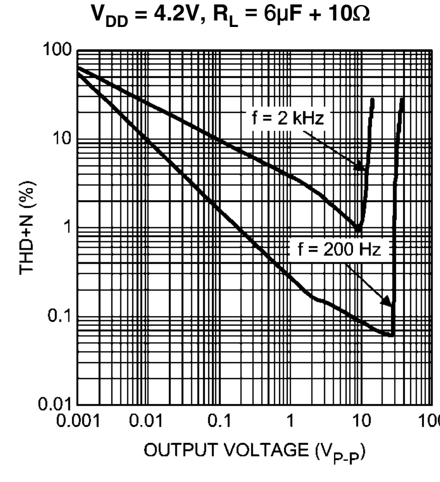
Output Voltage vs Frequency
V_{DD} = 4.2V, THD+N = 5%
R_L = 6μF + 10Ω



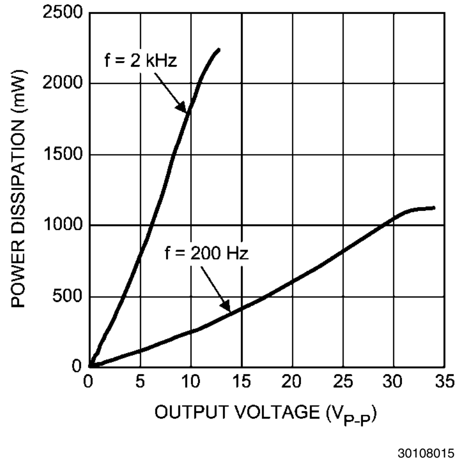
THD+N vs Output Voltage
V_{DD} = 3.6V, R_L = 6μF + 10Ω



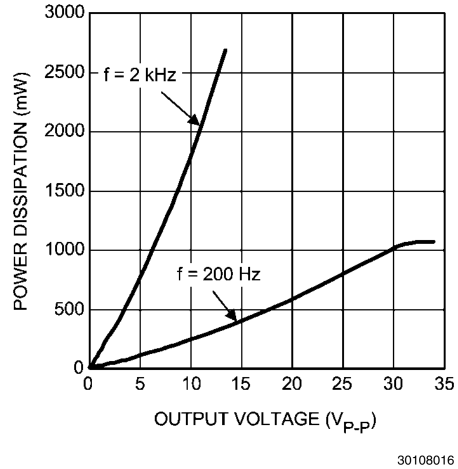
THD+N vs Output Voltage
V_{DD} = 4.2V, R_L = 6μF + 10Ω



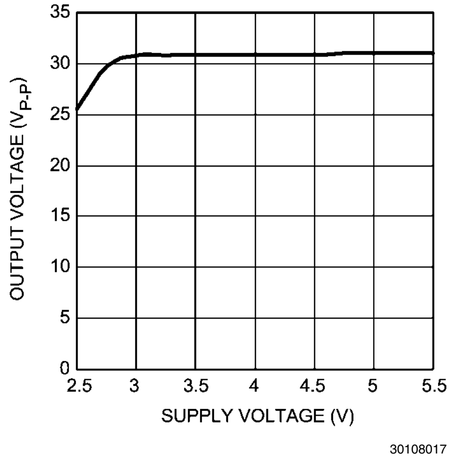
Power Consumption vs Output Voltage
V_{DD} = 3.6V, R_L = 6μF + 10Ω



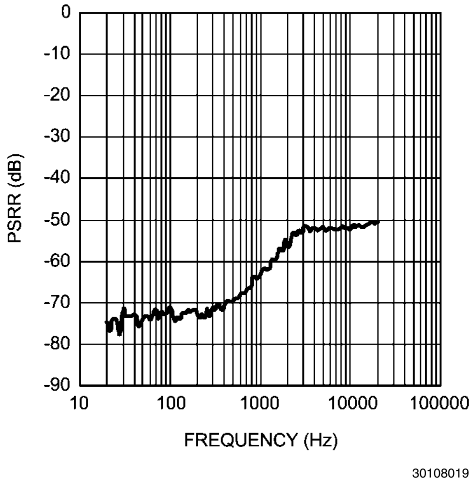
Power Consumption vs Output Voltage
V_{DD} = 4.2V, R_L = 6μF + 10Ω



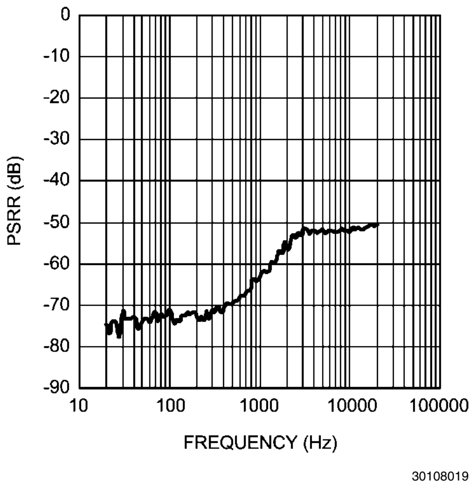
Output Voltage vs Supply Voltage
R_L = 6μF + 10Ω, f = 200Hz



PSRR vs Frequency
V_{DD} = 3.6V, V_{RIPPLE} = 200mV_{P-P}
R_L = 6μF + 10Ω, f = 200Hz



CMRR vs Frequency
V_{DD} = 3.6V, V_{CM} = 1V_{P-P}
R_L = 6μF + 10Ω



Application Information

GENERAL AMPLIFIER FUNCTION

The LM48580 is a fully differential, Class H ceramic element driver for ceramic speakers and haptic actuators. The integrated, high efficiency boost converter dynamically adjusts the amplifier's supply voltage based on the output signal, increasing headroom and improving efficiency compared to a conventional Class AB driver. The fully differential amplifier takes advantage of the increased headroom and bridge-tied load (BTL) architecture, delivering significantly more voltage than a single-ended amplifier.

CLASS H OPERATION

Class H is a modification of another amplifier class (typically Class B or Class AB) to increase efficiency and reduce power dissipation. To decrease power dissipation, Class H uses a tracking power supply that monitors the output signal and adjusts the supply accordingly. When the amplifier output is below $3V_{P-P}$, the nominal boost voltage is 6V. As the amplifier output increases above $3V_{P-P}$, the boost voltage tracks the amplifier output as shown in Figure 4. When the amplifier output falls below $3V_{P-P}$, the boost converter returns to its nominal output voltage. Power dissipation is greatly reduced compared to conventional Class AB drivers.

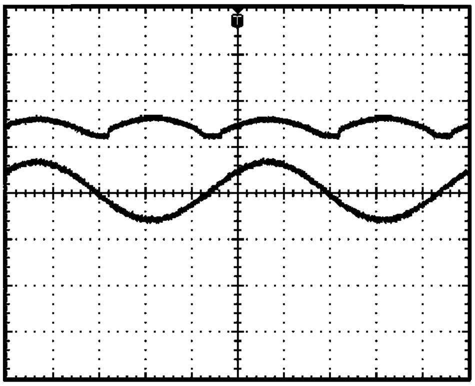


FIGURE 4. Class H Operation

PROPERTIES OF PIEZOELECTRIC ELEMENTS

Piezoelectric elements such as ceramic speakers or piezoelectric haptic actuators are capacitive in nature. Due to their capacitive nature, piezoelectric elements appear as low impedance loads at high frequencies (typically above 5kHz). A resistor in series with the piezoelectric element is required to ensure the amplifier does not see a short at high frequencies.

The value of the series resistor depends on the capacitance of the element, the frequency content of the output signal, and the desired frequency response. Higher valued resistors minimize power dissipation at high frequencies, but also impacts the frequency response. This configuration is ideal for use with haptic actuators, where the majority of the signal content is typically below 2kHz. Conversely, lower valued resistors maximize frequency response, while increasing power dissipation at high frequency. This configuration is ideal for ceramic speaker applications, where high frequency audio content needs to be reproduced. Resistor values are typically between 10Ω and 20Ω.

DIFFERENTIAL AMPLIFIER EXPLANATION

The LM48580 features a fully differential amplifier. A differential amplifier amplifies the difference between the two input signals. A major benefit of the fully differential amplifier is the improved common mode rejection ratio (CMRR) over single ended input amplifiers. The increased CMRR of the differential amplifier reduces sensitivity to ground offset related noise injection, especially important in noisy systems.

THERMAL SHUTDOWN

The LM48580 features thermal shutdown that protects the device during thermal overload conditions. When the junction temperature exceeds +160°C, the device is disabled. The LM48580 remains disabled until the die temperature falls below the +160°C and $\overline{SHDN}$ is toggled.

GAIN SETTING

The LM48580 features three internally configured gain settings 18, 24, and 30dB. The device gain is selected through a single pin (GAIN). The gain settings are shown in Table 2.

TABLE 2. Gain Setting

Gain	Gain Setting
FLOAT	18dB
GND	24dB
VDD	30dB

SHUTDOWN FUNCTION

The LM48580 features a low current shutdown mode. Set $\overline{SD}$ = GND to disable the amplifier and boost converter and reduce supply current to 0.01µA.

SINGLE-ENDED INPUT CONFIGURATION

The LM48580 is compatible with single-ended sources. When configured for single-ended inputs, input capacitors must be used to block and DC component at the input of the device. Figure 5 shows the typical single-ended applications circuit.

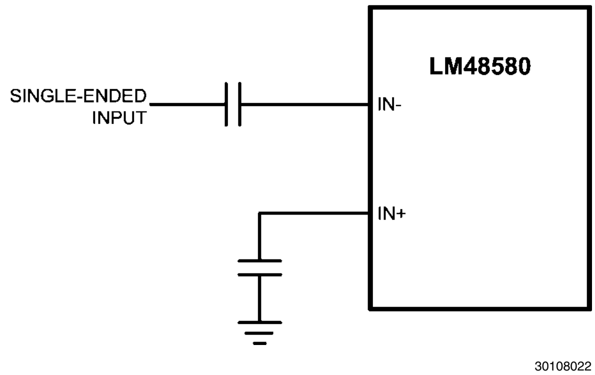


FIGURE 5. Single-Ended Configuration

PROPER SELECTION OF EXTERNAL COMPONENTS

Boost Converter Capacitor Selection

The LM48580 boost converter requires three external capacitors for proper operation: a 1µF supply bypass capacitor, and 1µF + 100pF output reservoir capacitors. Place the supply bypass capacitor as close to V_{DD} as possible. Place the reservoir capacitors as close to VBST and VAMP as possible. Low ESR surface-mount multi-layer ceramic capacitors with X7R or X5R temperature characteristics are recommended. Select output capacitors with voltage rating of 25V or higher. Tantalum, OS-CON and aluminum electrolytic capacitors are not recommended. See Table 4 for suggested capacitor manufacturers.

BOOST CONVERTER OUTPUT CAPACITOR SELECTION

Inductor Selection

The LM48580 boost converter is designed for use with a 4.7µH inductor. Table 3 lists various inductors and their manufacturers. Choose an inductor with a saturation current rating greater than the maximum operating peak current of the LM48580 (> 1A). This ensures that the inductor does not saturate, preventing excess efficiency loss, over heating and possible damage to the inductor. Additionally, choose an inductor with the lowest possible DCR (series resistance) to further minimize efficiency losses.

TABLE 3. Recommended Inductors

MANUFACTURER	PART#	INDUCTANCE/ ISAT
Taiyo Yuden	BRL3225T4R7M	4.7µH/1.1A
Coilcraft	LP3015	4.7µH/1.1A

Diode Selection

Use a Schottkey diode as shown in Figure 1. A 20V diode such as the NSR0520V2T1G from On Semiconductor is recommended. The NSR0520V2T1G is designed to handle a maximum average current of 500mA.

PCB LAYOUT GUIDELINES

Minimize trace impedance of the power, ground and all output traces for optimum performance. Voltage loss due to trace resistance between the LM48580 and the load results in decreased output power and efficiency. Trace resistance between the power supply and ground has the same effect as a poorly regulated supply, increased ripple and reduced peak output power. Use wide traces for power supply inputs and amplifier outputs to minimize losses due to trace resistance, as well as route heat away from the device. Proper grounding improves audio performance, minimizes crosstalk between channels and prevents switching noise from interfering with the audio signal. Use of power and ground planes is recommended.

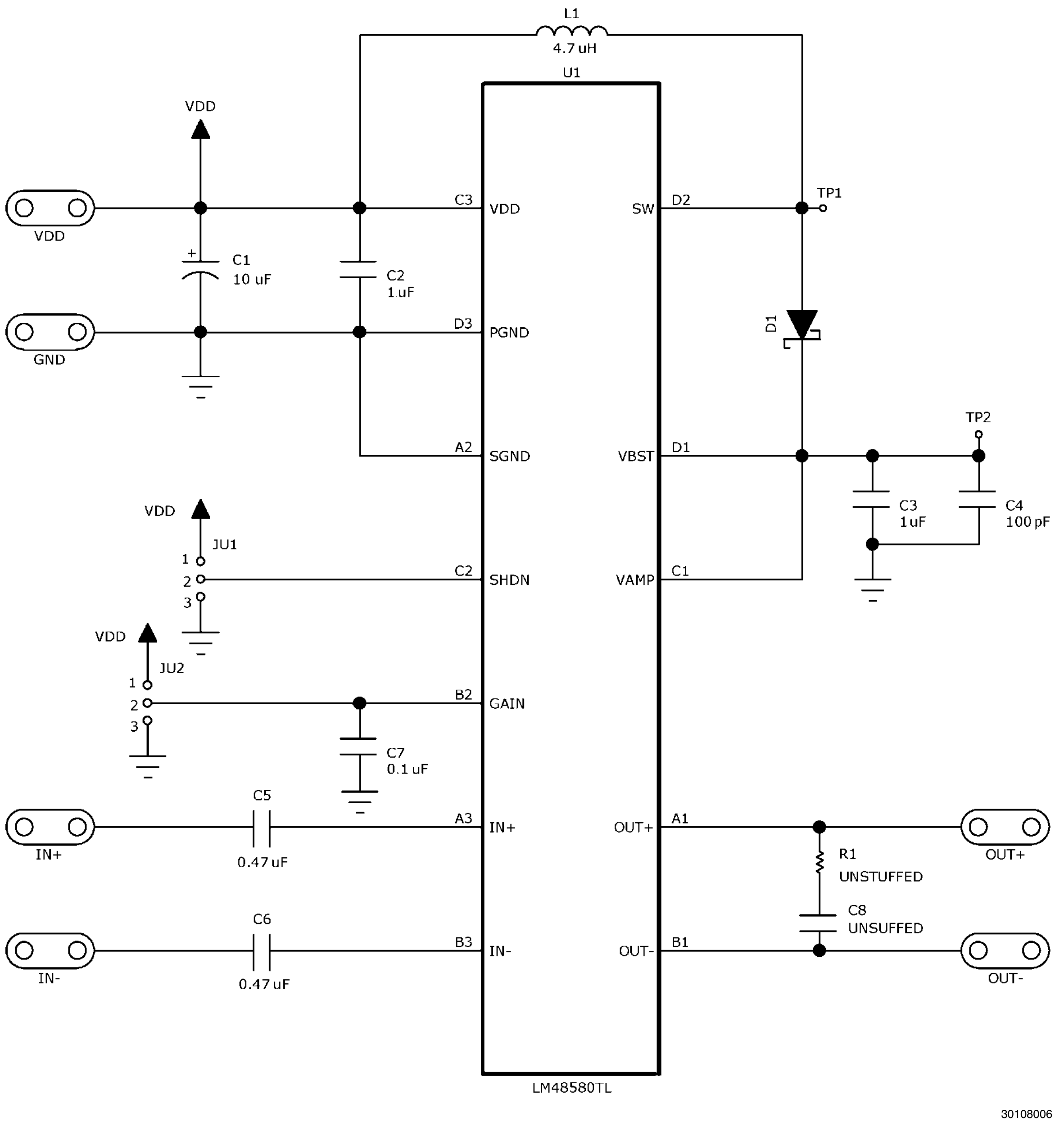
Place all digital components and route digital signal traces as far as possible from analog components and traces. Do not run digital and analog traces in parallel on the same PCB layer. If digital and analog signal lines must cross either over or under each other, ensure that they cross in a perpendicular fashion.

Demoboard Bill of Materials

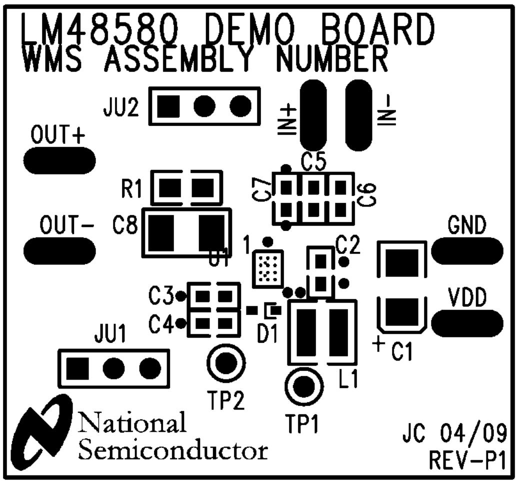
TABLE 4. Demoboard Bill of Materials

DESIGNATOR	QUANTITY	DESCRIPTION
C1	1	10µF ±10% 16V
		Tantalum Capacitor (B Case)
		AVX TPSB106K016R0800
C2	1	1µF ±10% 16V X5R
		Ceramic Capacitor (603)
		Panasonic ECJ-1VB1C105K
		Murata GRM188R61C105KA93D
C3	1	1µF ±10% 25V X5R
		Ceramic Capacitor (603)
		Panasonic ECJ-1VB1E105K
		Murata GRM188R61E105KA12D
C4	1	100pF ±5% 50V C0G
		Ceramic Capacitor (603)
		Panasonic ECJ-1VC1H101J
		Murata GRM1885C1H101JA01D
C5, C6	2	4.7µF ±10% 10V X5R
		Ceramic Capacitor (603)
		Panasonic ECJ-1VB1A474K
		Murata GRM188R61A474KA61D
C7	1	0.1µF ±10% 50V X7R
		Ceramic Capacitor (603)
		Panasonic ECJ-1VB1H104K
		Murata GRM188R71H104KA93D
C8	UNSTUFFED	
D1	1	20V, 500mA
		Schottky Diode (SOD-523)
		ON Semiconductor NSR0520V2T1G
L1	1	4.7µH ±20% 1.1A Inductor
		Taiyo Yuden BRL3225T4R7M
JU1, JU2	2	3-Pin Header
LM48580TL	1	LM48580TL (12-Bump microSMD)

Demo Board Schematic



PC Board Layout



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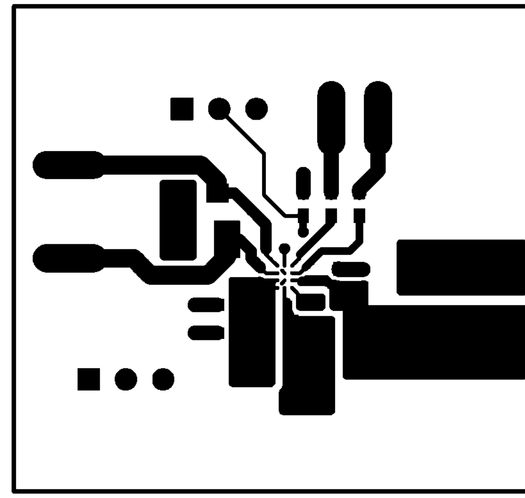
Top Silk Screen



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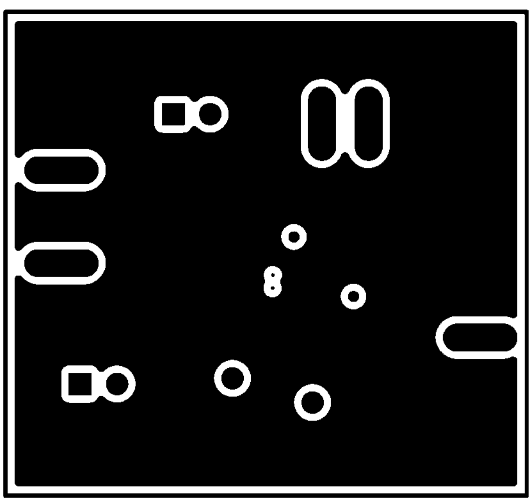
Top Layer



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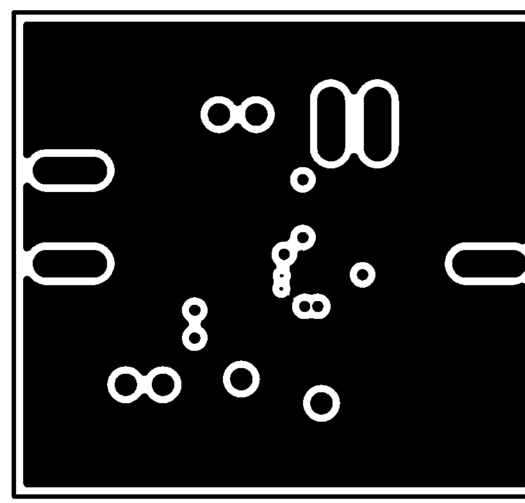
Layer 2



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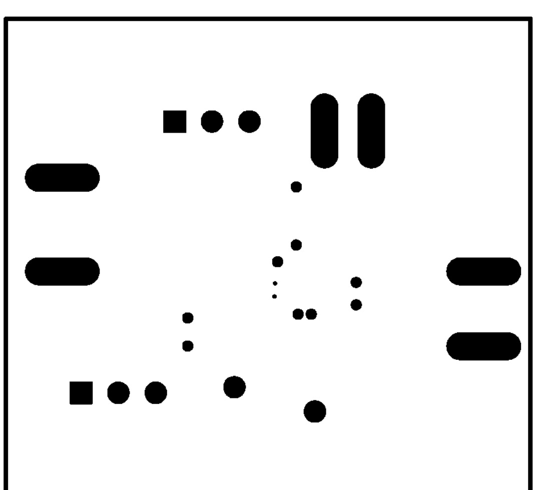
Layer 3



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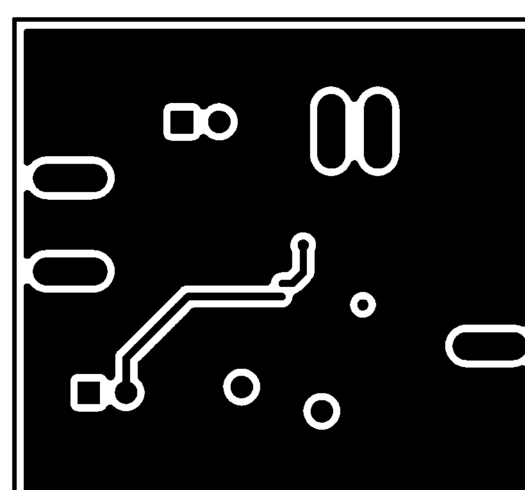
Bottom Silkscreen



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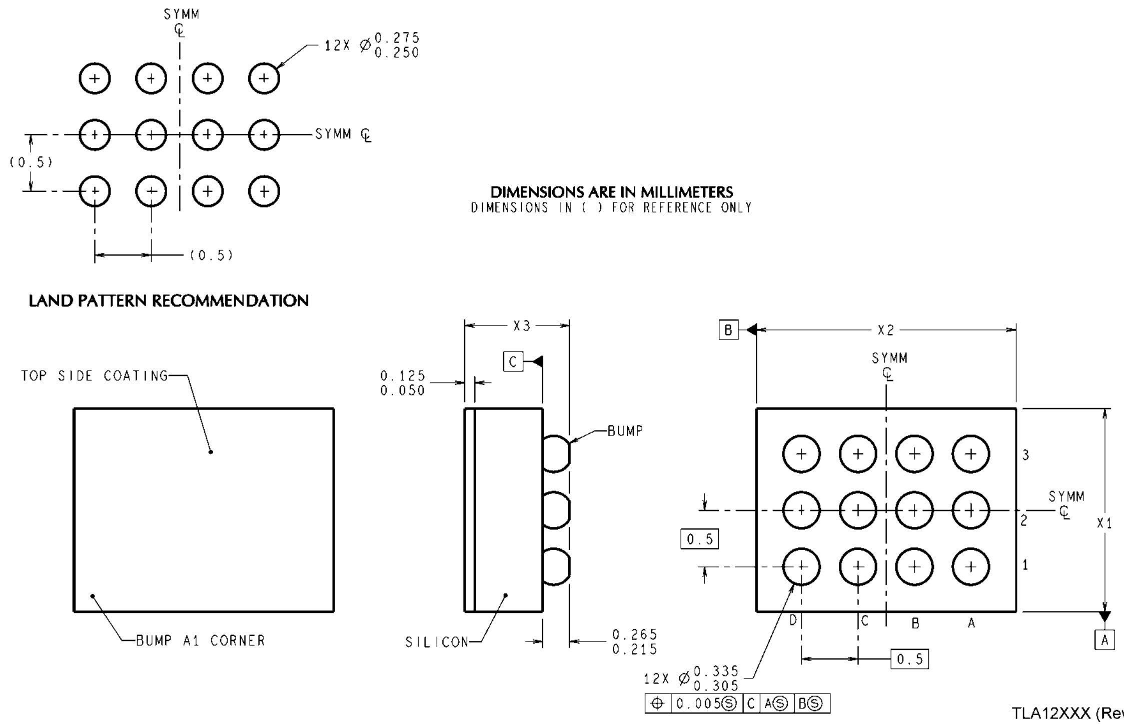
Bottom Layer

Revision History

Rev	Date	Description
1.0	02/23/10	Initial released.

Physical Dimensions inches (millimeters) unless otherwise noted



TLA12XXX (Rev C)

Thin micro SMD
Order Number LM48580TL
NS Package Number TLA12Z1A
X1 = 1.463±0.03mm X2 = 1.970±0.03mm X3 = 0.600±0.075mm

Notes

Notes

For more National Semiconductor product information and proven design tools, visit the following Web sites at: www.national.com

Products		Design Support	
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