# LM48580 Boomer™ Audio Power Amplifier Series High Efficiency Class H, High Voltage, Haptic Piezo Actuator / Ceramic Speaker Driver

**Check for Samples: LM48580**

## 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 DSBGA package**

## APPLICATIONS

- **Touch Screen Smart Phones**
- **Tablet PCs**
- **Portable Electronic Devices**
- **MP3 Players**

## 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)**

## DESCRIPTION

The LM48580 is a fully differential, high voltage driver for piezo actuators and ceramic speakers for portable multi-media devices. Part of TI'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 DSBGA package (1.46mm x 1.97mm).

## Typical Application

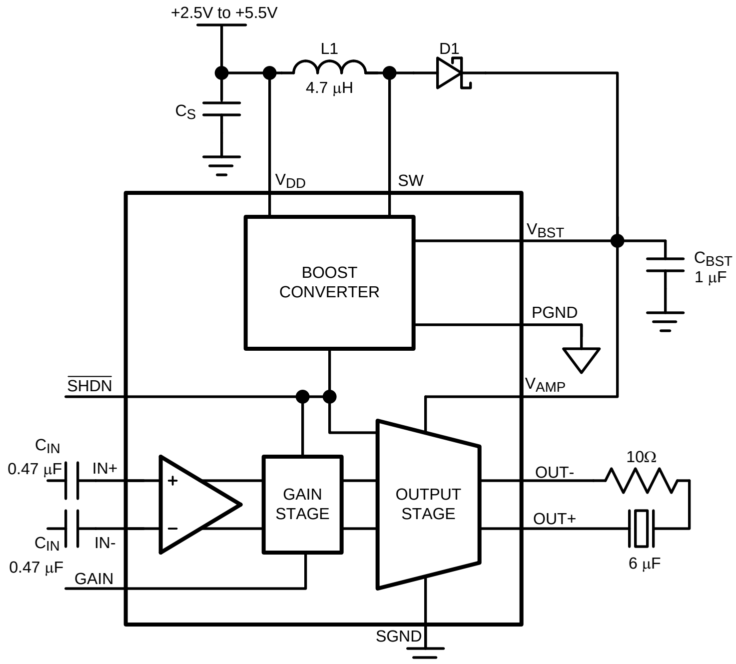



**Figure 1. Typical Application Circuit**

## Connection Diagram

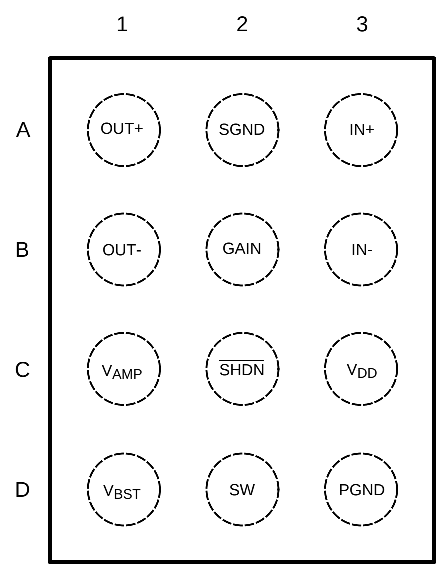



**Figure 2. DSBGA Package**
**1.46mm x 1.97mm x 0.6mm**
**Top View**
**See Package Number YZR0012**

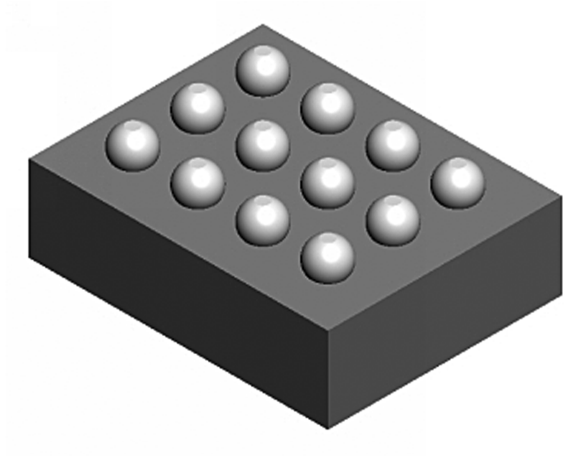


**Figure 3. YZR0012 Package View (Bumps Up)**

## PIN 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:<br>GAIN = float: $A_V$ = 18dB<br>GAIN = GND: $A_V$ = 24dB<br>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.<br>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 |

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## Absolute Maximum Ratings(1)(2)(3)

| | | |
|---|---|---|
| Supply Voltage(1) | | 6V |
| SW Voltage | | 25V |
| VBST Voltage | | 21V |
| $V_{AMP}$ | | 17V |
| Input Voltage | | −0.3V to $V_{DD}$ + 0.3V |
| Power Dissipation(4) | | Internally limited |
| ESD Rating | Human Body Model(5) | 2kV |
| | Machine Model(6) | 150V |
| | Charge Device Model(7) | 750V |
| Storage Temperature | | −65°C to + 150°C |
| Junction Temperature | | 150°C |
| Thermal Resistance | $\theta_{JA}$ (YZR0012) | 64 °C/W |
| Soldering Information | See AN-1112 (SNVA009) "DSBGA Wafer Level Chip Scale Package." | |

(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.
(2) The *Electrical Characteristics* tables list ensured 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 ensured.
(3) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(4) The maximum power dissipation must be derated at elevated temperatures and is dictated by $T_{JMAX}$, $\theta_{JA}$, 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.
(5) Human body model, applicable std. JESD22-A114C.
(6) Machine model, applicable std. JESD22-A115-A.
(7) Charge device model, applicable std. JESD22-C101-C.

## Operating Ratings

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

## Electrical Characteristics $V_{DD}$ = 3.6V [1][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 [3] | LM48580 Typ [4] | Max [3] | 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<br>GAIN = GND<br>GAIN = $V_{DD}$ | 17.5<br>23.5<br>29.5 | 18<br>24<br>30 | 18.5<br>24.5<br>30.5 | dB<br>dB<br>dB |
| $R_{IN}$ | Input Resistance | | 46 | 52 | 58 | kΩ |
| $R_{IN}$ | Gain Input Resistance | to GND<br>to $V_{DD}$ | | | 575<br>131 | kΩ<br>kΩ |
| $V_{IN}$ | Maximum Input Voltage Range | $A_V$ = 18dB | | | 3 | $V_{P-P}$ |
| $V_{OUT}$ | Output Voltage | f = 200Hz, THD+N = 1%<br>$V_{DD}$ = 3.6V<br>$V_{DD}$ = 3V | <br><br>25 | <br>30.5<br>30.5 | | <br>$V_{P-P}$<br>$V_{P-P}$ |
| | | f = 2kHz, THD+N = 5%<br>$V_{DD}$ = 3.6V<br>$V_{DD}$ = 3V | | <br>11<br>8.5 | | <br>$V_{P-P}$<br>$V_{P-P}$ |
| THD+N | Total Harmonic Distortion + Noise | $V_{OUT}$ = 25$V_{P-P}$, f = 200Hz | | 0.16 | | % |
| PSRR | Power Supply Rejection Ratio (Figure TBD) | $V_{DD}$ = 3.6V + 200m$V_{p-p}$ sine, Inputs AC GND | | | | |
| | | $f_{RIPPLE}$ = 217Hz,<br>$f_{RIPPLE}$ = 1kHz | | 75<br>71 | | dB<br>dB |
| CMRR | Common Mode Rejection Ratio (Figure TBD) | $V_{CM}$ = 200m$V_{P-P}$ sine | | | | |
| | | $f_{RIPPLE}$ = 217Hz<br>$f_{RIPPLE}$ = 1kHz | | 56<br>55 | | dB<br>dB |
| $f_{SW}$ | 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 |

(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.
(2) The *Electrical Characteristics* tables list ensured 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 ensured.
(3) Datasheet min/max specification limits are specified by design, test, or statistical analysis.
(4) 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 specified.

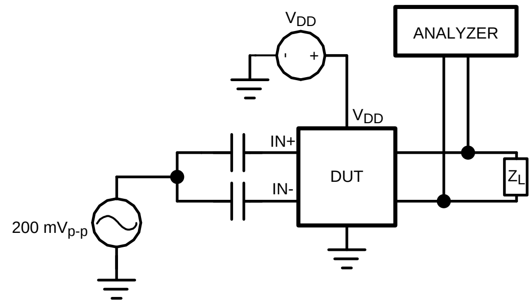



**Figure 4. PSRR Test Circuit**

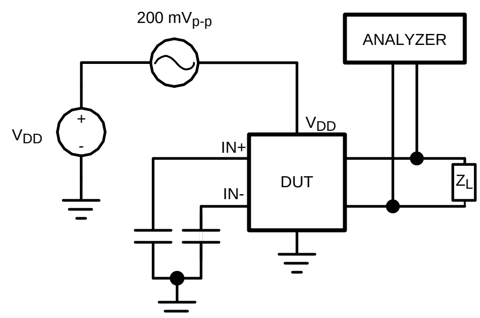



**Figure 5. CMRR Test Circuit**

## Typical Performance Characteristics

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

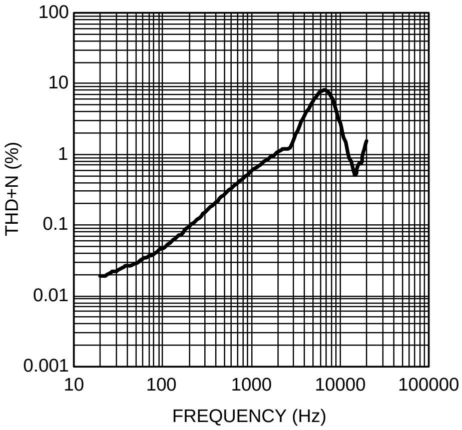



**Figure 6.**

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

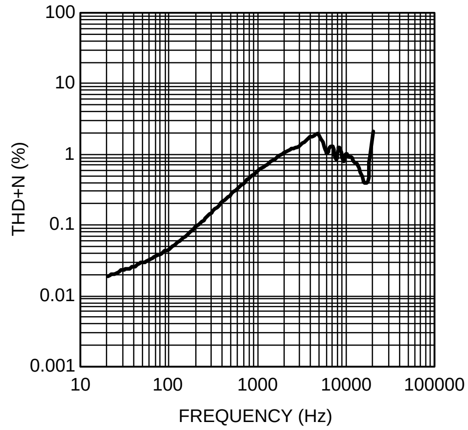



**Figure 7.**

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

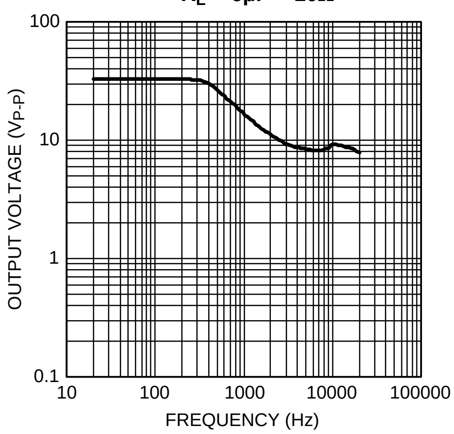



**Figure 8.**

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

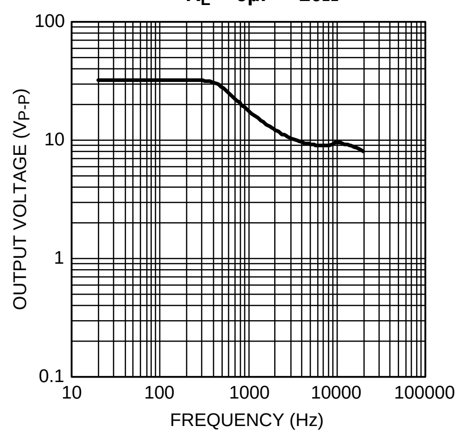



**Figure 9.**

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

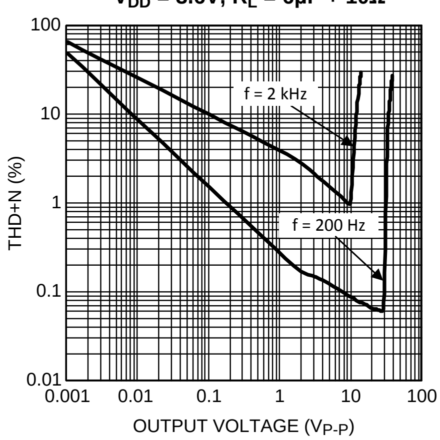



**Figure 10.**

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

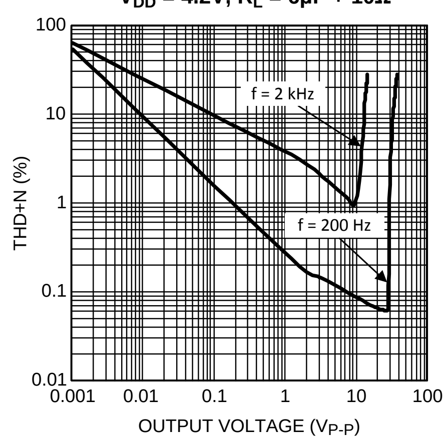



**Figure 11.**

## Typical Performance Characteristics (continued)

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

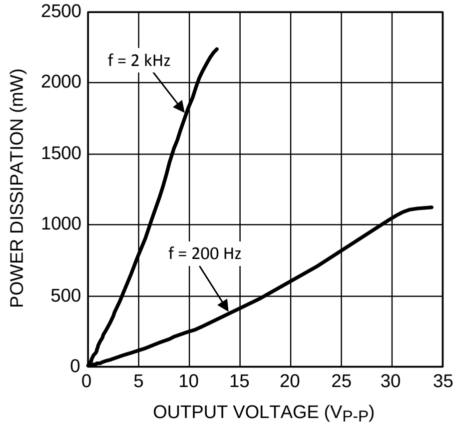



**Figure 12.**

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

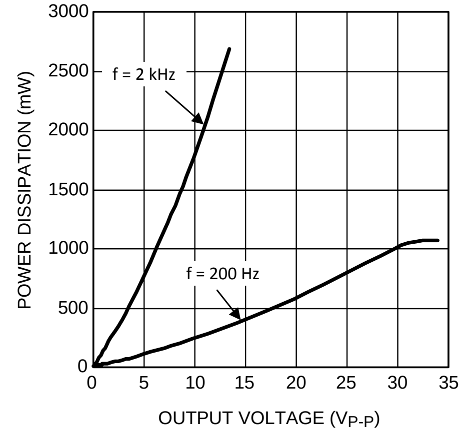



**Figure 13.**

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

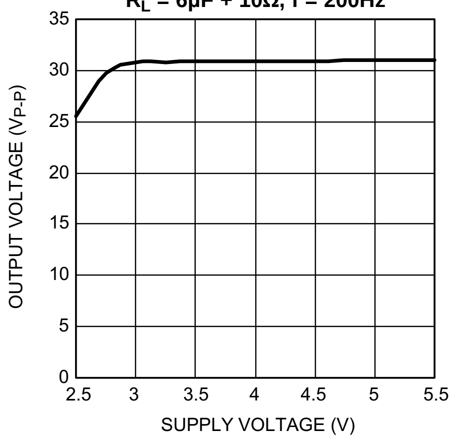



**Figure 14.**

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

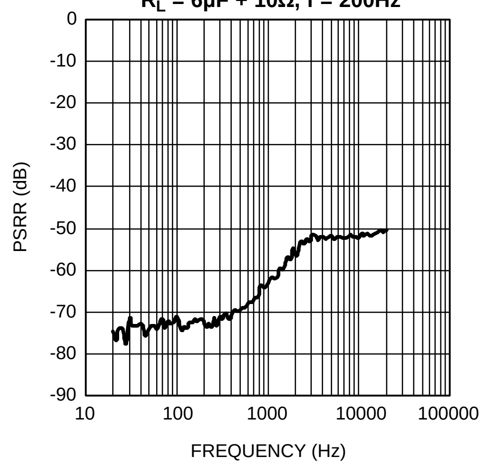



**Figure 15.**

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

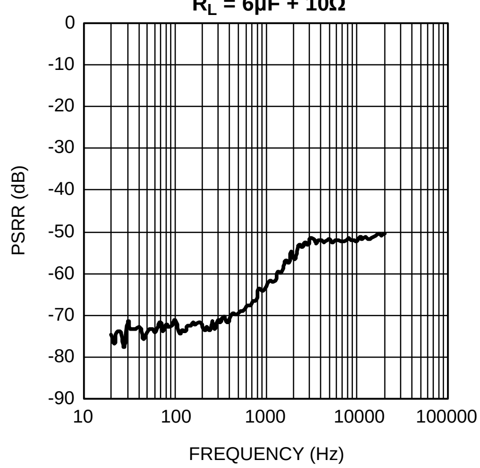



**Figure 16.**

# 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 17. 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.

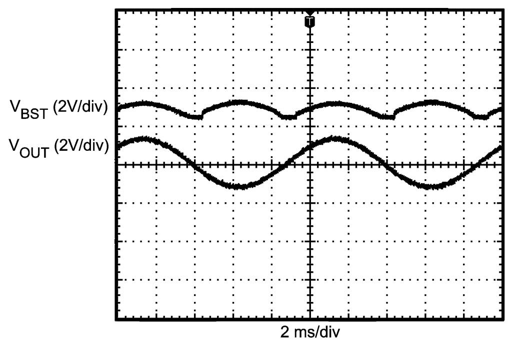



**Figure 17. Class H Operation**

## 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 1.

**Table 1. 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 18 shows the typical single-ended applications circuit.

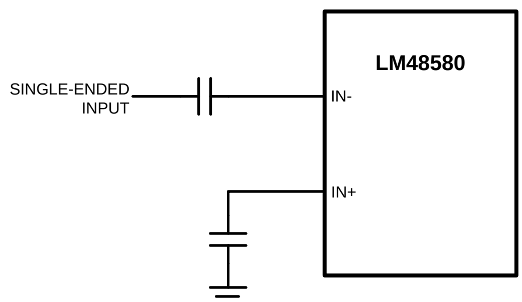



**Figure 18. Single-Ended Configuration**

## 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 Demoboard Bill of Materials 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 2 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 2. 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

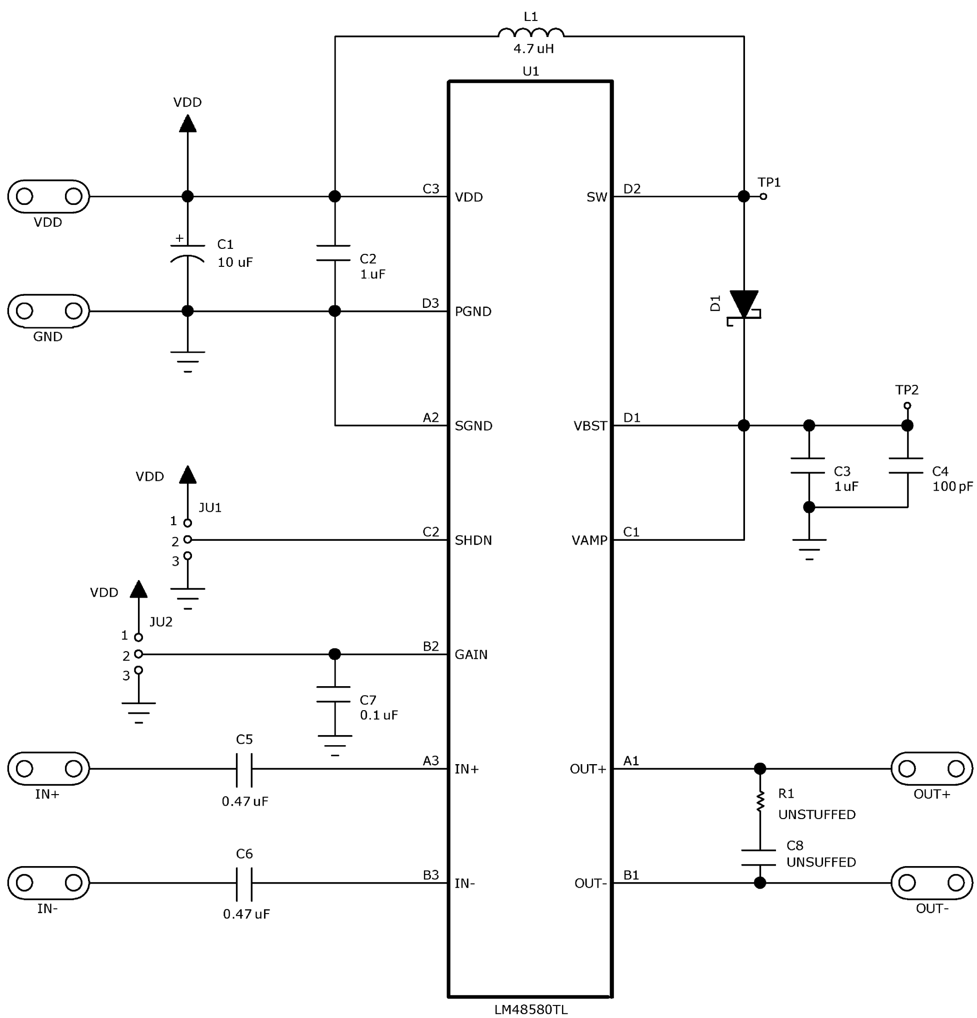
**Table 3. Demoboard Bill of Materials**

| 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 | |

### Table 3. Demoboard Bill of Materials (continued)

| DESIGNATOR | QUANTITY | DESCRIPTION |
|---|---|---|
| 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 DSBGA) |

## Demo Board Schematic



## PC Board Layout

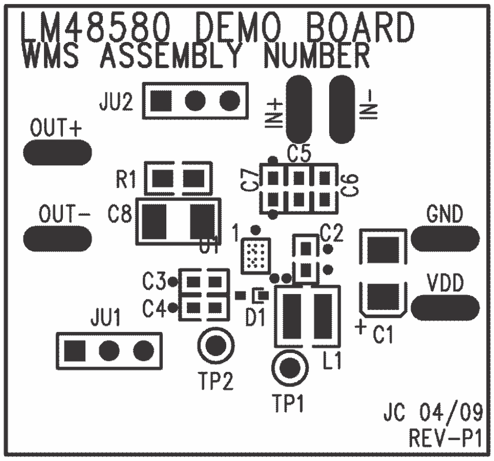



Figure 19. Top Silk Screen

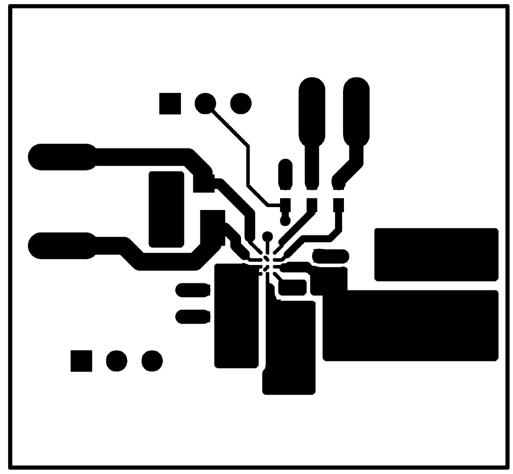


Figure 20. Top Layer

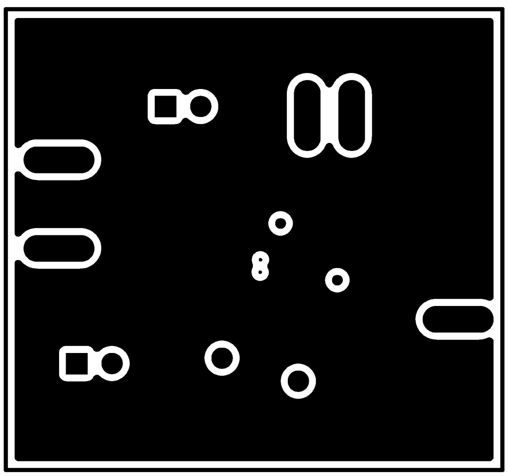


Figure 21. Layer 2

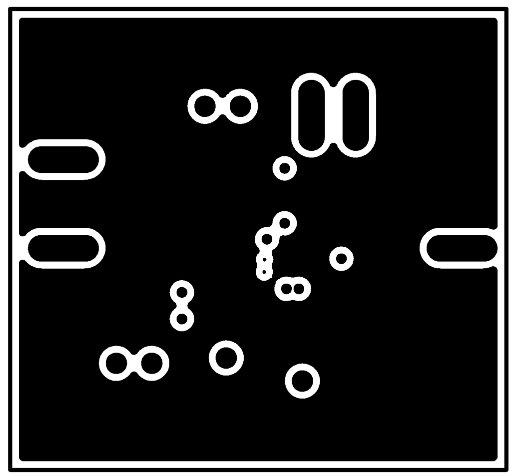


Figure 22. Layer 3

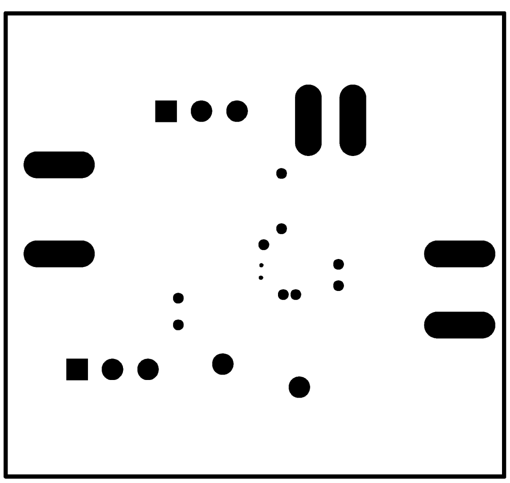


Figure 23. Bottom Silkscreen

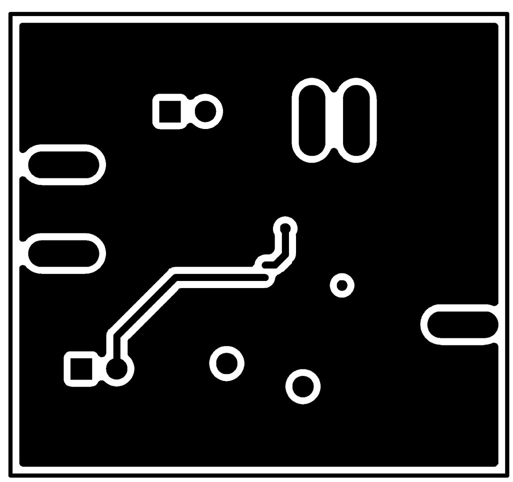


Figure 24. Bottom Layer

## Revision History

| Rev | Date | Description |
|---|---|---|
| 1.0 | 02/23/10 | Initial released. |
| A | 05/02/2013 | Changed layout of National Data Sheet to TI format. |

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Op Temp (°C) | Top-Side Markings (4) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LM48580TL/NOPB | ACTIVE | DSBGA | YZR | 12 | 250 | Green (RoHS & no Sb/Br) | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | GM3 | Samples |
| LM48580TLX/NOPB | ACTIVE | DSBGA | YZR | 12 | 3000 | Green (RoHS & no Sb/Br) | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | GM3 | Samples |

(1) The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.
**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
**TBD:** The Pb-Free/Green conversion plan has not been defined.
**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

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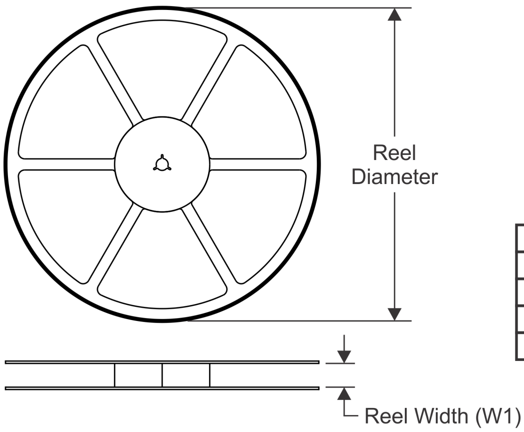
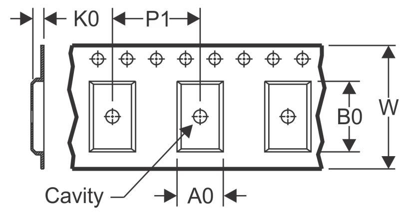
## TAPE AND REEL INFORMATION

### REEL DIMENSIONS

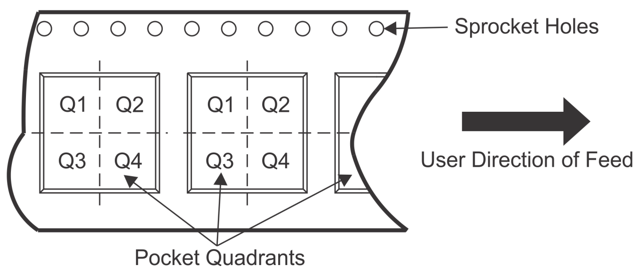



### TAPE DIMENSIONS




| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

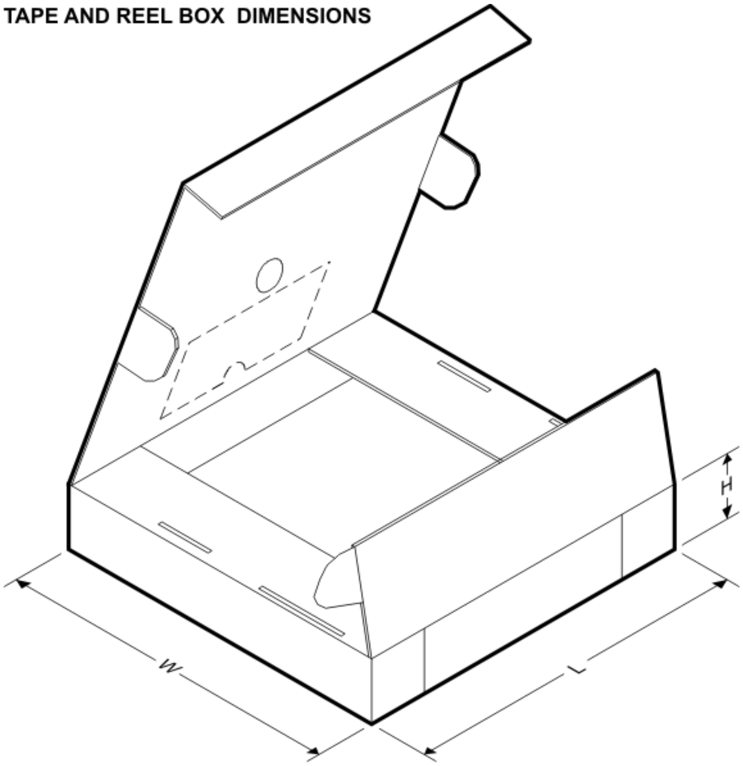
### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE




*All dimensions are nominal

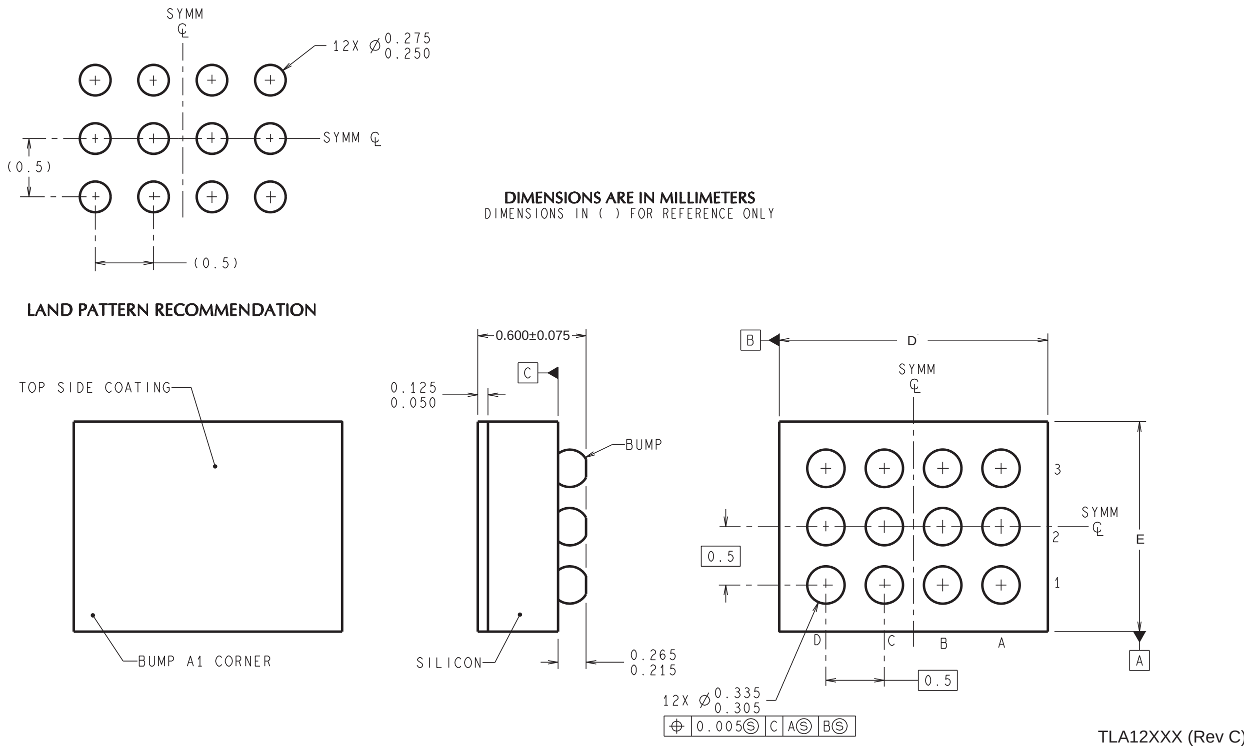
| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LM48580TL/NOPB | DSBGA | YZR | 12 | 250 | 178.0 | 8.4 | 1.68 | 2.13 | 0.76 | 4.0 | 8.0 | Q1 |
| LM48580TLX/NOPB | DSBGA | YZR | 12 | 3000 | 178.0 | 8.4 | 1.68 | 2.13 | 0.76 | 4.0 | 8.0 | Q1 |

**TAPE AND REEL BOX DIMENSIONS**




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| LM48580TL/NOPB | DSBGA | YZR | 12 | 250 | 210.0 | 185.0 | 35.0 |
| LM48580TLX/NOPB | DSBGA | YZR | 12 | 3000 | 210.0 | 185.0 | 35.0 |




D: Max = 1.99 mm, Min = 1.93 mm

E: Max = 1.49 mm, Min = 1.43 mm

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NOTES: A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
B. This drawing is subject to change without notice.