# LM48860 Boomer® Audio Power Amplifier Series Ground-Referenced, Ultra Low Noise, Fixed Gain Stereo Headphone Amplifier

**Check for Samples: LM48860**

## FEATURES

- **Fixed Logic Levels with Supply Voltage**
- **Ground Referenced Outputs**
- **High PSRR**
- **Available in Space-Saving DSBGA Package**
- **Ultra Low Current Shutdown Mode**
- **Improved Pop & Click Circuitry Eliminates Noises During Turn-On and Turn-Off Transitions**
- **No Output Coupling Capacitors, Snubber Networks, Bootstrap Capacitors, or Gain-Setting Resistors Required**
- **Shutdown Either Channel Independently**

## APPLICATIONS

- **Mobile Phones**
- **MP3 Players**
- **PDAs**
- **Portable Electronic Devices**
- **Notebook PCs**

## KEY SPECIFICATIONS

- **PSRR at 217Hz ($V_{DD}$ = 3.0V): 80dB (typ)**
- **Stereo Power Output at $V_{DD}$ = 3V, $R_L$ = 16Ω, THD+N = 1%: 40mW (typ)**
- **Shutdown Current 0.1µA (typ)**
- **Internal Fixed Gain: 1.5V/V (typ)**
- **Operating Voltage: 2.0V to 5.5V**

## DESCRIPTION

The LM48860 is a ground referenced, fixed-gain audio power amplifier capable of delivering 40mW per channel of continuous average power into a 16Ω single-ended load with less than 1% THD+N from a 3V power supply.

The LM48860 features a new circuit technology that utilizes a charge pump to generate a negative reference voltage. This allows the outputs to be biased about ground, thereby eliminating output-coupling capacitors typically used with normal single-ended loads.

Boomer audio power amplifiers were designed specifically to provide high quality output power with a minimal amount of external components. The LM48860 does not require output coupling capacitors or bootstrap capacitors, and therefore is ideally suited for mobile phone and other low voltage applications where minimal power consumption is a primary requirement.

The LM48860 features a low-power consumption shutdown mode selectable for either channel separately. This is accomplished by driving either the $\overline{SD_RC}$ (Shutdown Right Channel) or $\overline{SD_LC}$ (Shutdown Left Channel) (or both) pins with logic low, depending on which channel is desired shutdown. Additionally, the LM48860 features an internal thermal shutdown protection mechanism.

The LM48860 contains advanced pop & click circuitry that eliminates noises which would otherwise occur during turn-on and turn-off transitions.

The LM48860 has an internal fixed gain of 1.5V/V.

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## Typical Application

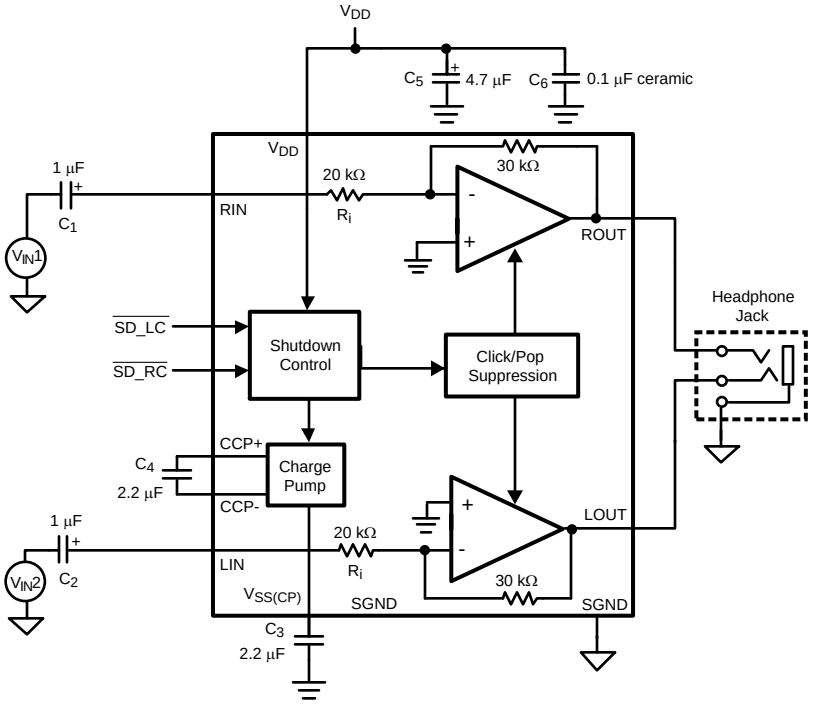


**Figure 1. Typical Audio Amplifier Application Circuit**

## Connection Diagram

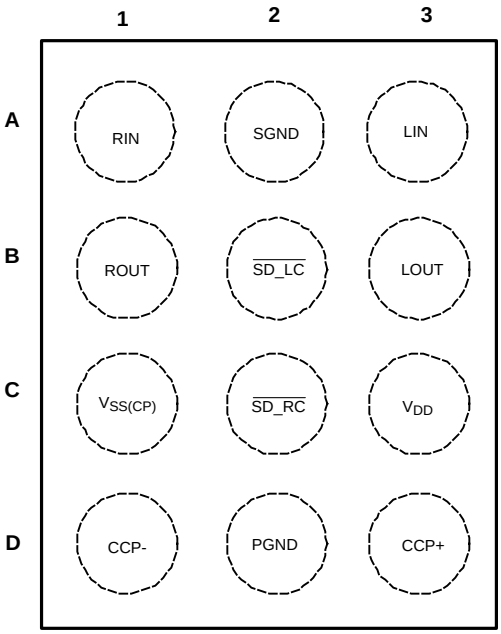


**Figure 2. DSBGA - Top View**
**See YZR0012 Package**


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## PIN DESCRIPTIONS

| Pin | Name | Function |
|---|---|---|
| A1 | RIN | Right Channel Input |
| A2 | SGND | Signal Ground |
| A3 | LIN | Left Channel Input |
| B1 | ROUT | Right Channel Output |
| B2 | $\overline{SD_LC}$ | Active Low Shutdown, Left Channel |
| B3 | LOUT | Left Channel Output |
| C1 | $V_{SS(CP)}$ | Charge Pump Voltage Output |
| C2 | $\overline{SD_RC}$ | Active-Low Shutdown, Right Channel |
| C3 | $V_{DD}$ | Supply Voltage |
| D1 | CCP- | Negative Terminal - Charge Pump Flying Capacitor |
| D2 | PGND | Power Ground |
| D3 | CCP+ | Positive Terminal - Charge Pump Flying Capacitor |

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)

| | |
|---|---|
| Supply Voltage | 6.0V |
| Storage Temperature | −65°C to +150°C |
| Input Voltage | -0.3V to $V_{DD}$ |
| Power Dissipation(3) | Internally Limited |
| ESD Rating(4) | 2000V |
| ESD Rating(5) | 200V |
| Junction Temperature | 150°C |
| Thermal Resistance | |
| $\theta_{JA}$ (typ) DSBGA | 59.3°C/W |

(1) The *Electrical Characteristics* tables list ensure 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 specified.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.
(3) 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 number given in *Absolute Maximum Ratings*, whichever is lower. For the LM48860, see power derating curves for additional information.
(4) Human body model, applicable std. JESD22-A114C.
(5) Machine model, applicable std. JESD22-A115-A.

## Operating Ratings

| | |
|---|---|
| Temperature Range | |
| $T_{MIN} \le T_A \le T_{MAX}$ | $-40°C \le T_A \le 85°C$ |
| Supply Voltage ($V_{DD}$) | $2.0V \le V_{DD} \le 5.5V$ |

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## Electrical Characteristics $V_{DD}$ = 3V (1)(2)

The following specifications apply for $V_{DD}$ = 3V and 16Ω load unless otherwise specified. Limits apply to $T_A$ = 25°C.

| Symbol | Parameter | Conditions | LM48860 | | Units (Limits) |
|---|---|---|---|---|---|
| | | | Typical(3) | Limit(4) | |
| $I_{DD}$ | Quiescent Power Supply Current Full Power Mode | $V_{DD}$ = 3.0V, $V_{IN}$ = 0V, inputs terminated both channels enabled | 4 | 5.5 | mA (max) |
| | | $V_{DD}$ = 5.0V, $V_{IN}$ = 0V, inputs terminated both channels enabled | 4.2 | | mA |
| $I_{SD}$ | Shutdown Current | SD_LC = SD_RC= GND | 0.1 | 1 | µA (max) |
| | | SD_LC = SD_RC= GND, $V_{DD}$ = 5.0V | 0.1 | 1 | µA (max) |
| $V_{OS}$ | Output Offset Voltage | $R_L$ = 32Ω, $V_{IN}$ = 0V | 0.7 | 5.5 | mV (max) |
| $A_V$ | Voltage Gain | | –1.5 | | V/V |
| $\Delta A_V$ | Channel-to-channel Gain Matching | | 1 | | % |
| $R_{IN}$ | Input Resistance | | 20 | 15<br>25 | kΩ (min)<br>kΩ (max) |
| $P_O$ | Output Power | THD+N = 1% (max); f = 1kHz, $R_L$ = 16Ω, (two channels in phase) | 40 | 35 | mW (min) |
| | | THD+N = 1% (max); f = 1kHz, $R_L$ = 32Ω, (two channels in phase) | 50 | 40 | mW (min) |
| THD+N | Total Harmonic Distortion + Noise | $P_O$ = 20mW, f = 1kHz, $R_L$ = 16Ω (two channels in phase) | 0.025 | | % |
| | | $P_O$ = 25mW, f = 1kHz, $R_L$ = 32Ω (two channels in phase) | 0.014 | | % |
| PSRR | Power Supply Rejection Ratio Full Power Mode | $V_{RIPPLE}$ = 200m$V_{PP}$, Input Referred | | | |
| | | f = 217Hz | 80 | 73 | dB (min) |
| | | f = 1kHz | 75 | | dB |
| | | f = 20kHz | 60 | | dB |
| SNR | Signal-to-Noise Ratio | $R_L$ = 32Ω, $P_{OUT}$ = 50mW, f = 1kHz, BW = 20Hz to 22kHz, A-weighted | 105 | | dB |
| $V_{IH}$ | Shutdown Input Voltage High | $V_{DD}$ = 2.0V to 5.5V | | 1.2 | V (min) |
| $V_{IL}$ | Shutdown Input Voltage Low | $V_{DD}$ = 2.0V to 5.5V | | 0.45 | V (max) |
| $X_{TALK}$ | Crosstalk | $R_L$ = 16Ω, $P_O$ = 1.6mW, f = 1kHz | 75 | | dB |
| $\epsilon_{OS}$ | Output Noise | A-weighted filter, $V_{IN}$ = 0V | 8 | | µV |
| $Z_{OUT}$ | Output Impedance | $V_{SD}$ = GND<br>Input Terminated<br>Input not terminated<br>SD_LC = SD_RC = GND | <br>30<br>30 | 20 | <br>kΩ (min)<br>kΩ |
| $I_L$ | Input Leakage | | ±0.1 | | nA |

(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 ensure 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 specified.

(3) 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.

(4) Datasheet min/max specification limits are ensured by test or statistical analysis.


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## External Components Description

(Figure 1)

| Components | | Functional Description |
|---|---|---|
| 1. | $C_1$ | Input coupling capacitor which blocks the DC voltage at the amplifier's input terminals. Also creates a high pass-pass filter with $R_i$ at $f_C = 1/(2R_iC_1)$. Refer to the section Proper Selection of External Components, for an explanation of how to determine the value of $C_1$. |
| 2. | $C_2$ | Input coupling capacitor which blocks the DC voltage at the amplifier's input terminals. Also creates a high pass-pass filter with $R_i$ at $f_C = 1/(2R_iC_2)$. Refer to the Power Supply Bypassing section for an explanation of how to determine the value of $C_2$. |
| 3. | $C_3$ | Output capacitor. Low ESR ceramic capacitor (≤100mΩ) |
| 4. | $C_4$ | Flying capacitor. Low ESR ceramic capacitor (≤100mΩ) |
| 5. | $C_5$ | Tantalum capacitor. Supply bypass capacitor which provides power supply filtering. Refer to the Power Supply Bypassing section for information concerning proper placement and selection of the supply bypass capacitor. |
| 6. | $C_6$ | Ceramic capacitor. Supply bypass capacitor which provides power supply filtering. Refer to the Power Supply Bypassing section for information concerning proper placement and selection of the supply bypass capacitor. |

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## Typical Performance Characteristics

**THD+N vs Output Power**
**$V_{DD}$ = 3V, $R_L$ = 16Ω**
**f = 1kHz, 22kHz BW, one channel enabled**

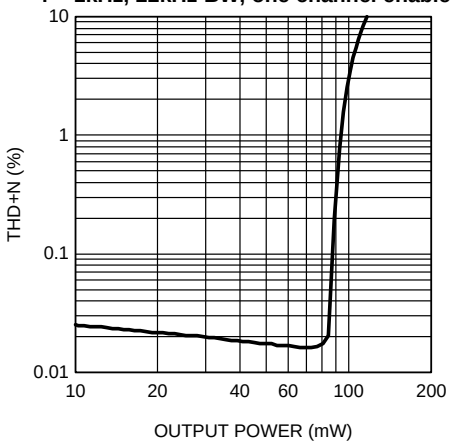


**Figure 3.**

**THD+N vs Output Power**
**$V_{DD}$ = 3V, $R_L$ = 16Ω, f = 1kHz**
**22kHz BW, two channels in phase**

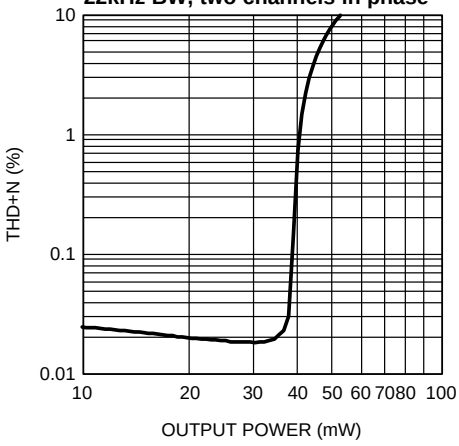


**Figure 4.**

**THD+N vs Output Power**
**$V_{DD}$ = 3V, $R_L$ = 32Ω**
**f = 1kHz, 22kHz BW, one channel enabled**

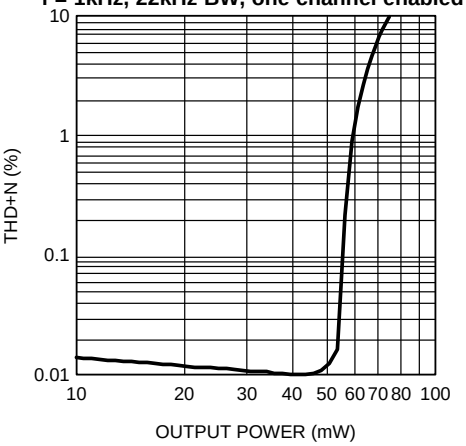


**Figure 5.**

**THD+N vs Output Power**
**$V_{DD}$ = 3V, $R_L$ = 32Ω, f = 1kHz**
**22kHz BW, two channels in phase**

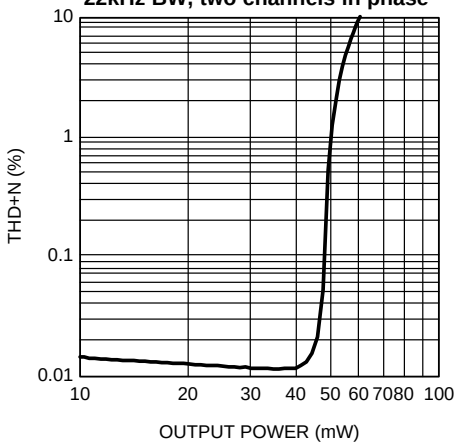


**Figure 6.**

**THD+N vs Output Power**
**$V_{DD}$ = 3.6V, $R_L$ = 16Ω**
**f = 1kHz, 22kHz BW, one channel enabled**

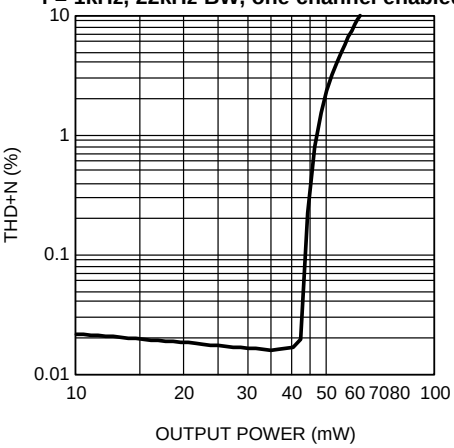


**Figure 7.**

**THD+N vs Output Power**
**$V_{DD}$ = 3.6V, $R_L$ = 16Ω, f = 1kHz**
**22kHz BW, two channels in phase**

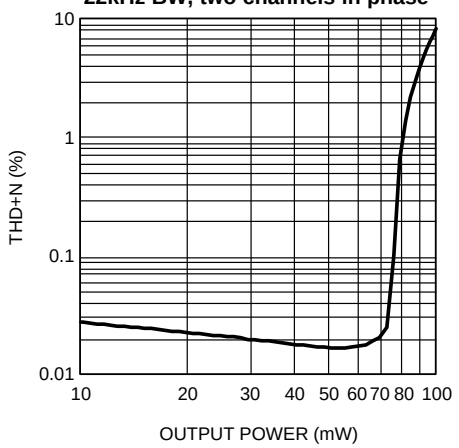


**Figure 8.**


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## Typical Performance Characteristics (continued)

**THD+N vs Output Power**
**$V_{DD}$ = 3.6V, $R_L$ = 32Ω**
**f = 1kHz, 22kHz BW, one channel enabled**

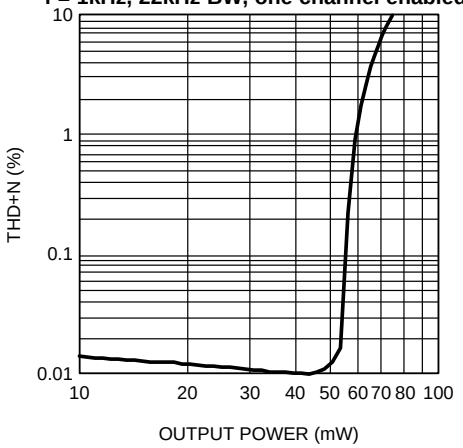


**Figure 9.**

**THD+N vs Output Power**
**$V_{DD}$ = 3.6V, $R_L$ = 32Ω, f = 1kHz**
**22kHz BW, two channels in phase**

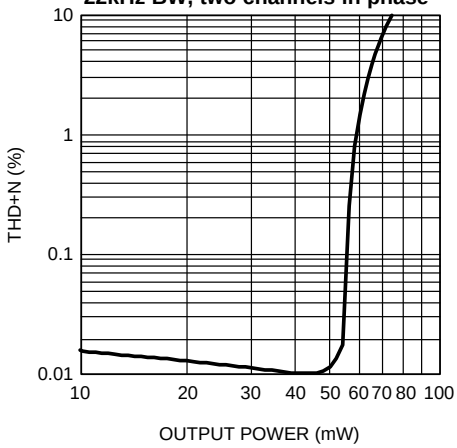


**Figure 10.**

**THD+N vs Output Power**
**$V_{DD}$ = 4.2V, $R_L$ = 16Ω**
**f = 1kHz, 22kHz BW, one channel enabled**

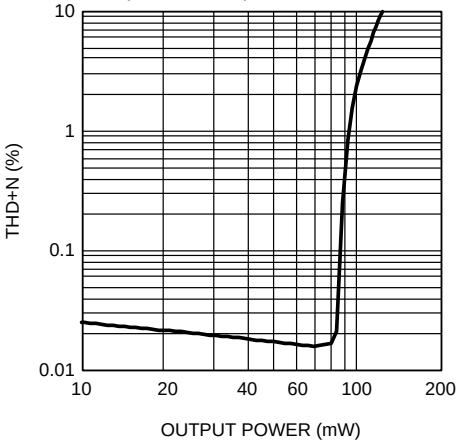


**Figure 11.**

**THD+N vs Output Power**
**$V_{DD}$ = 4.2V, $R_L$ = 16Ω, f = 1kHz**
**22kHz BW, two channels in phase**

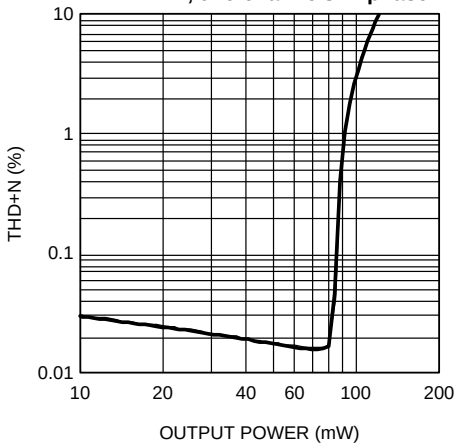


**Figure 12.**

**THD+N vs Output Power**
**$V_{DD}$ = 4.2V, $R_L$ = 32Ω**
**f = 1kHz, 22kHz BW, one channel enabled**

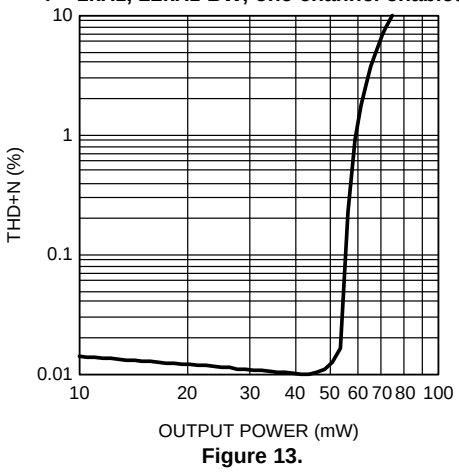


**Figure 13.**

**THD+N vs Output Power**
**$V_{DD}$ = 4.2V, $R_L$ = 32Ω, f = 1kHz**
**22kHz BW, two channels in phase**

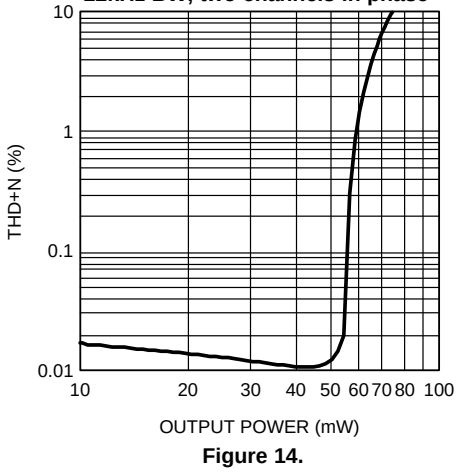


**Figure 14.**

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## Typical Performance Characteristics (continued)

**THD+N vs Frequency**
**$V_{DD}$ = 3V, $R_L$ = 16Ω**
**$P_O$ = 20mW, 22kHz BW**

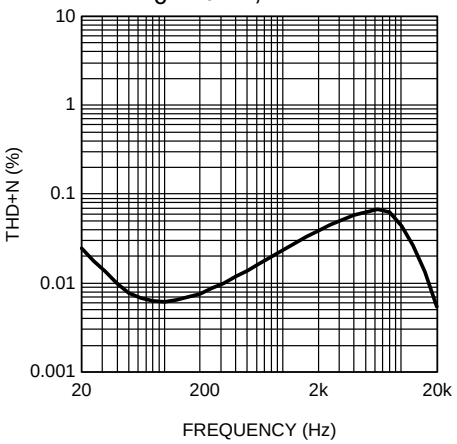


**Figure 15.**

**THD+N vs Frequency**
**$V_{DD}$ = 3V, $R_L$ = 32Ω**
**$P_O$ = 20mW, 22kHz BW**

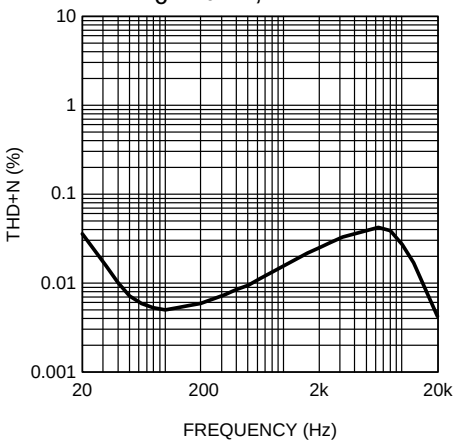


**Figure 16.**

**THD+N vs Frequency**
**$V_{DD}$ = 3.6V, $R_L$ = 16Ω**
**$P_O$ = 30mW, 22kHz BW**

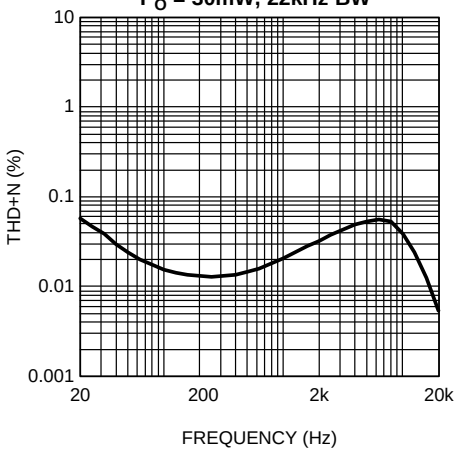


**Figure 17.**

**THD+N vs Frequency**
**$V_{DD}$ = 3.6V, $R_L$ = 32Ω**
**$P_O$ = 30mW, 22kHz BW**

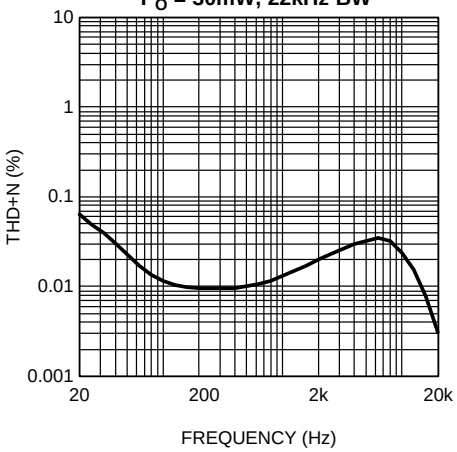


**Figure 18.**

**THD+N vs Frequency**
**$V_{DD}$ = 4.2V, $R_L$ = 16Ω**
**$P_O$ = 30mW, 22kHz BW**

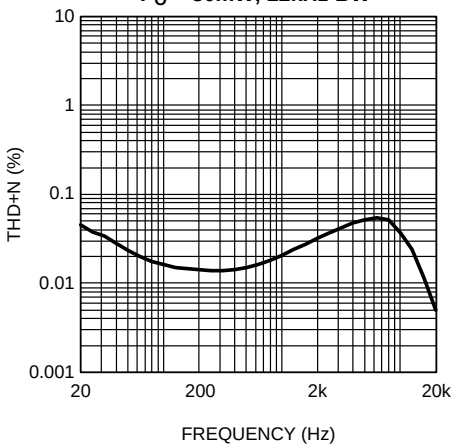


**Figure 19.**

**THD+N vs Frequency**
**$V_{DD}$ = 4.2V, $R_L$ = 32Ω**
**$P_O$ = 30mW, 22kHz BW**

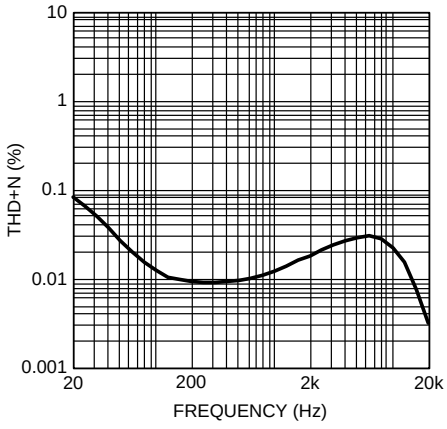


**Figure 20.**


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## Typical Performance Characteristics (continued)

**PSRR vs Frequency**
**$V_{DD}$ = 3V, $R_L$ = 16Ω**
**$V_{RIPPLE}$ = 200m$V_{PP}$**

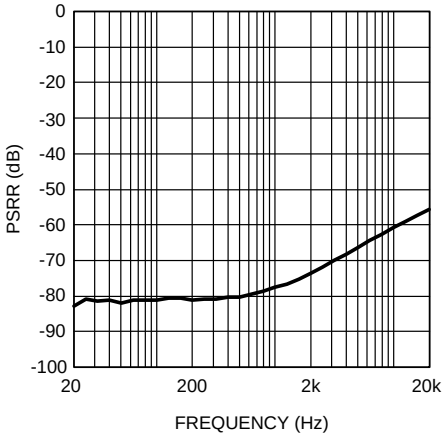


**Figure 21.**

**PSRR vs Frequency**
**$V_{DD}$ = 3V, $R_L$ = 32Ω**
**$V_{RIPPLE}$ = 200m$V_{PP}$**

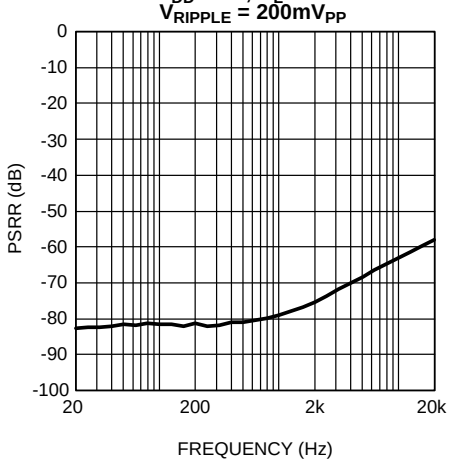


**Figure 22.**

**PSRR vs Frequency**
**$V_{DD}$ = 3.6V, $R_L$ = 16Ω**
**$V_{RIPPLE}$ = 200m$V_{PP}$**

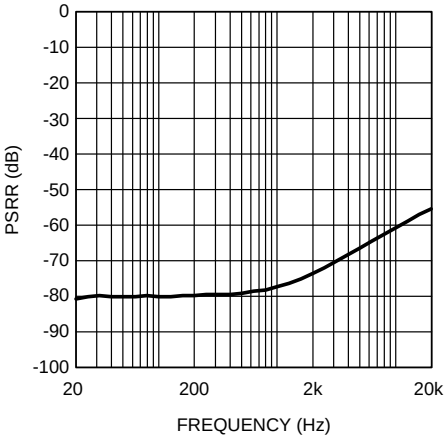


**Figure 23.**

**PSRR vs Frequency**
**$V_{DD}$ = 3.6V, $R_L$ = 32Ω**
**$V_{RIPPLE}$ = 200m$V_{PP}$**

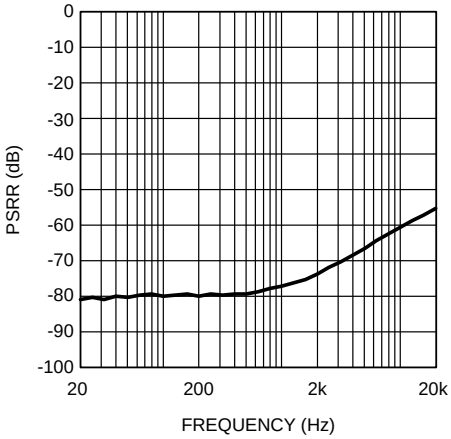


**Figure 24.**

**PSRR vs Frequency**
**$V_{DD}$ = 4.2V, $R_L$ = 16Ω**
**$V_{RIPPLE}$ = 200m$V_{PP}$**

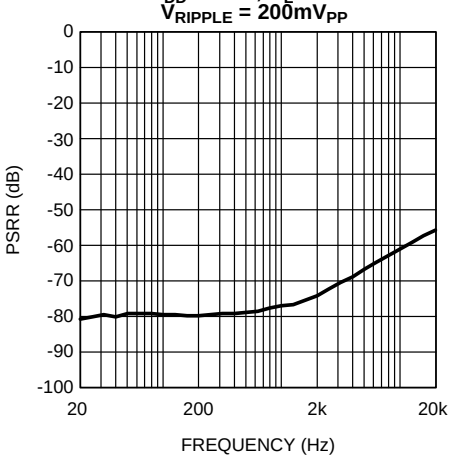


**Figure 25.**

**PSRR vs Frequency**
**$V_{DD}$ = 4.2V, $R_L$ = 32Ω**
**$V_{RIPPLE}$ = 200m$V_{PP}$**

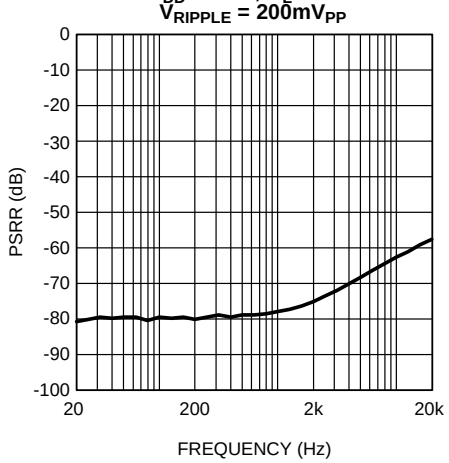


**Figure 26.**

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## Typical Performance Characteristics (continued)

**Output Power vs Supply Voltage**
**$R_L$ = 16Ω, f = 1kHz, 22kHz BW**

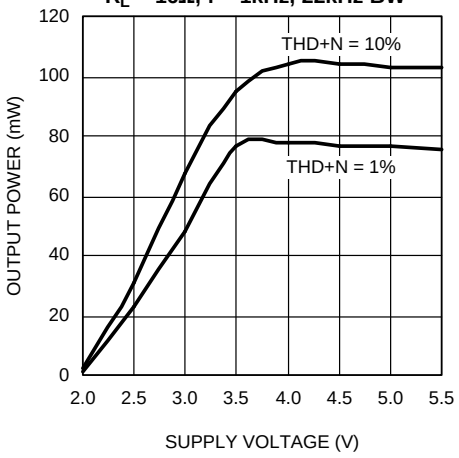


**Figure 27.**

**Output Power vs Supply Voltage**
**$R_L$ = 32Ω, f = 1kHz, 22kHz BW**

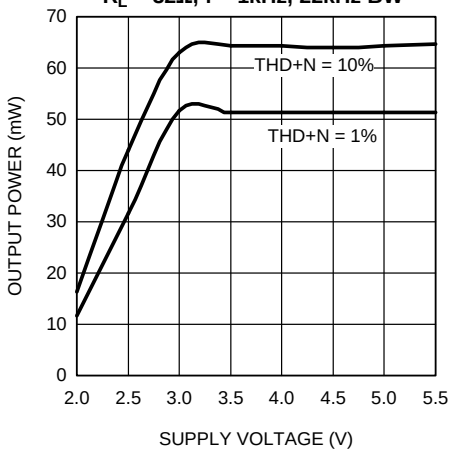


**Figure 28.**

**Power Dissipation vs Output Power**
**$V_{DD}$ = 3V, $R_L$ = 16Ω, f = 1kHz**

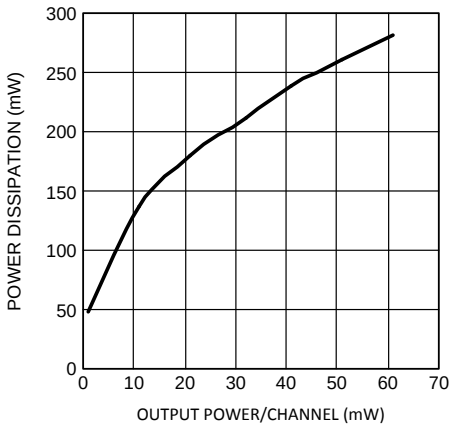


**Figure 29.**

**Power Dissipation vs Output Power**
**$V_{DD}$ = 3V, $R_L$ = 32Ω, f = 1kHz**

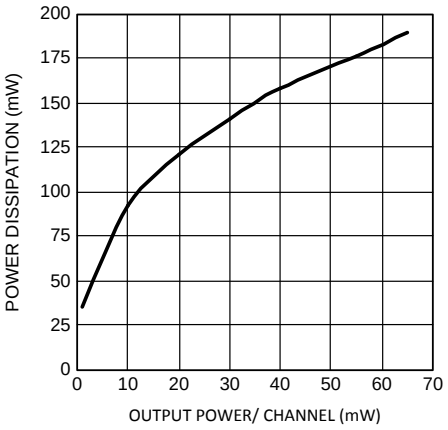


**Figure 30.**

**Power Dissipation vs Output Power**
**$V_{DD}$ = 5V, $R_L$ = 16Ω, f = 1kHz**

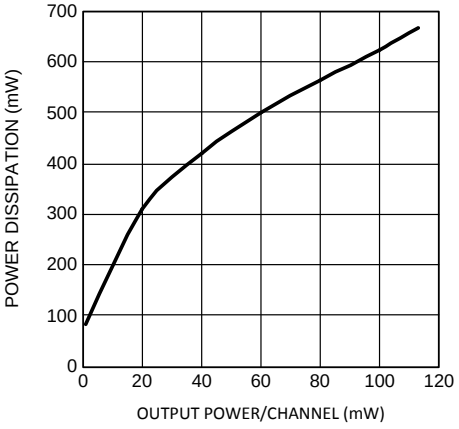


**Figure 31.**

**Power Dissipation vs Output Power**
**$V_{DD}$ = 5V, $R_L$ = 32Ω, f = 1kHz**

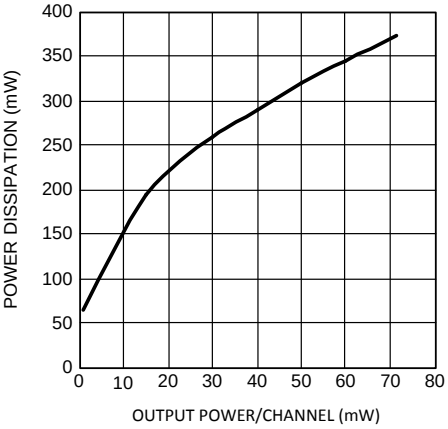


**Figure 32.**


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## Typical Performance Characteristics (continued)

**Supply Current vs Supply Voltage**
**$V_{IN}$ = GND, No Load**

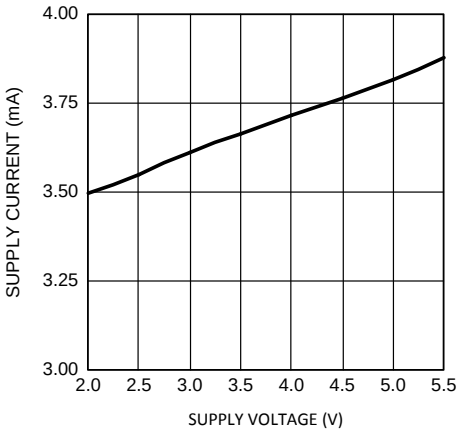


**Figure 33.**

**Power Derating Curve**
**$V_{DD}$ = 3V, $R_L$ = 16Ω**

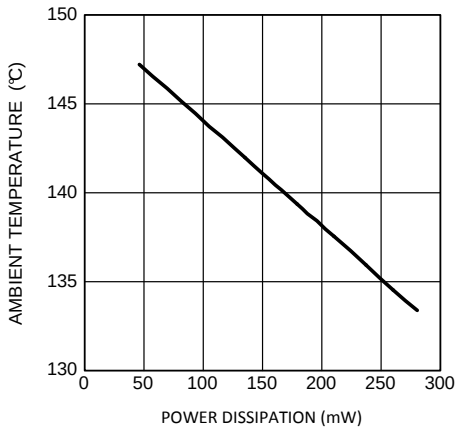


**Figure 34.**

**Power Derating Curve**
**$V_{DD}$ = 3V, $R_L$ = 32Ω**

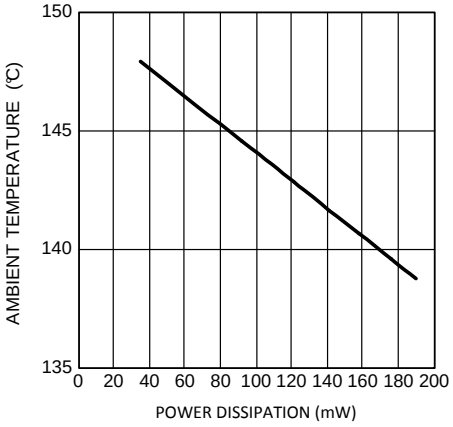


**Figure 35.**

**Power Derating Curve**
**$V_{DD}$ = 5V, $R_L$ = 16Ω**

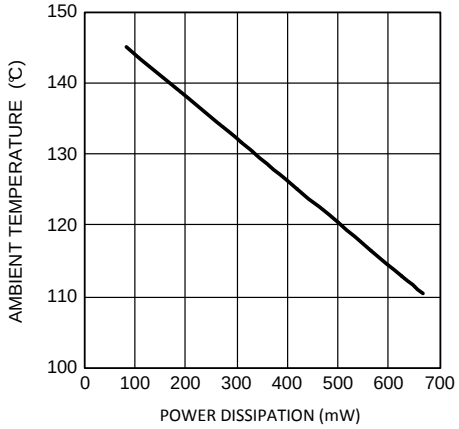


**Figure 36.**

**Power Derating Curve**
**$V_{DD}$ = 5V, $R_L$ = 32Ω**

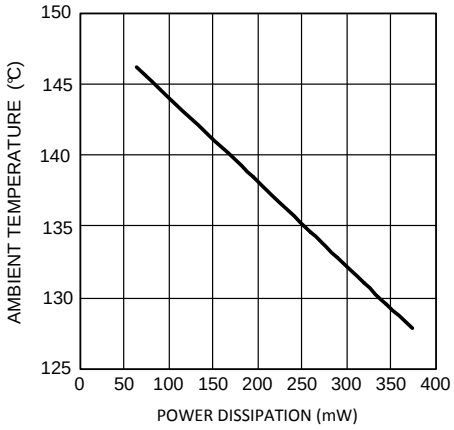


**Figure 37.**

# APPLICATION INFORMATION

## SUPPLY VOLTAGE SEQUENCING

It is a good general practice to first apply the supply voltage to a CMOS device before any other signal or supply on other pins. This is also true for the LM48860 audio amplifier which is a CMOS device.

Before applying any signal to the inputs or shutdown pins of the LM48860, it is important to apply a supply voltage to the $V_{DD}$ pins. After the device has been powered, signals may be applied to the shutdown pins (see MICRO POWER SHUTDOWN) and input pins.

## ELIMINATING THE OUTPUT COUPLING CAPACITOR

The LM48860 features a low noise inverting charge pump that generates an internal negative supply voltage. This allows the outputs of the LM48860 to be biased about GND instead of a nominal DC voltage, like traditional headphone amplifiers. Because there is no DC component, the large DC blocking capacitors (typically 220µF) are not necessary. The coupling capacitors are replaced by two, small ceramic charge pump capacitors, saving board space and cost.

Eliminating the output coupling capacitors also improves low frequency response. In traditional headphone amplifiers, the headphone impedance and the output capacitor form a high pass filter that not only blocks the DC component of the output, but also attenuates low frequencies, impacting the bass response. Because the LM48860 does not require the output coupling capacitors, the low frequency response of the device is not degraded by external components.

In addition to eliminating the output coupling capacitors, the ground referenced output nearly doubles the available dynamic range of the LM48860 when compared to a traditional headphone amplifier operating from the same supply voltage.

## OUTPUT TRANSIENT ('CLICK AND POPS') ELIMINATED

The LM48860 contains advanced circuitry that virtually eliminates output transients ('clicks and pops'). This circuitry prevents all traces of transients when the supply voltage is first applied or when the part resumes operation after coming out of shutdown mode.

## AMPLIFIER CONFIGURATION EXPLANATION

As shown in Figure 1, the LM48860 has two internal operational amplifiers. The two amplifiers have internally configured gain.

Since this is an output ground-referenced amplifier, the LM48860 does not require output coupling capacitors.

## POWER DISSIPATION

From the graph (THD+N vs Output Power , $V_{DD}$ = 3V, $R_L$ = 16Ω, f = 1kHz, 22kH BW, two channels in phase, page 6) assuming a 3V power supply and a 16Ω load, the maximum power dissipation point and thus the maximum package dissipation point is 281mW. The maximum power dissipation point obtained must not be greater than the power dissipation that results from Equation 1.

$$P_{DMAX} = (T_{JMAX} - T_A) / (\theta_{JA}) \quad (1)$$

For the DSBGA package $\theta_{JA}$ = 59.3°C/W. $T_{JMAX}$ = 150°C for the LM48860. Depending on the ambient temperature, $T_A$, of the system surroundings, Equation 1 can be used to find the maximum internal power dissipation supported by the IC packaging. If the maximum power dissipation from the graph is greater than that of Equation 1, then either the supply voltage must be decreased, the load impedance increased or $T_A$ reduced (see power derating curves). For the application of a 5V power supply, with a 16Ω load, the maximum ambient temperature possible without violating the maximum junction temperature is approximately 110°C provided that device operation is around the maximum power dissipation point. Power dissipation is a function of output power and thus, if typical operation is not around the maximum power dissipation point, the ambient temperature may be increased accordingly.


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## 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 3V power supply typically use a 4.7µF capacitor in parallel with a 0.1µF ceramic filter capacitor to stabilize the power supply's output, reduce noise on the supply line, and improve the supply's transient response. Keep the length of leads and traces that connect capacitors between the LM48860's power supply pin and ground as short as possible.

## MICRO POWER SHUTDOWN

The voltage applied to the $\overline{\text{SD_LC}}$ (shutdown left channel) pin and the $\overline{\text{SD_RC}}$ (shutdown right channel) pin controls the LM48860's shutdown function. When active, the LM48860's micropower shutdown feature turns off the amplifiers' bias circuitry, reducing the supply current. The trigger point is 0.45V for a logic-low level, and 1.2V for logic-high level. The low 0.01µA (typ) shutdown current is achieved by applying a voltage that is as near as ground a possible to the $\overline{\text{SD_LC}}$/$\overline{\text{SD_RC}}$ pins. A voltage that is higher than ground may increase the shutdown current. Do not let $\overline{\text{SD_LC}}$/$\overline{\text{SD_RC}}$ float, connect either to high or low.

## SELECTING PROPER EXTERNAL COMPONENTS

Optimizing the LM48860's performance requires properly selecting external components. Though the LM48860 operates well when using external components with wide tolerances, best performance is achieved by optimizing component values.

### Charge Pump Capacitor Selection

Use low ESR (equivalent series resistance) (<100mΩ) ceramic capacitors with an X7R dielectric for best performance. Low ESR capacitors keep the charge pump output impedance to a minimum, extending the headroom on the negative supply. Higher ESR capacitors result in reduced output power from the audio amplifiers.

Charge pump load regulation and output impedance are affected by the value of the flying capacitor (C4). A larger valued C4 (up to 3.3uF) improves load regulation and minimizes charge pump output resistance. Beyond 3.3uF, the switch-on resistance dominates the output impedance.

The output ripple is affected by the value and ESR of the output capacitor (C3). Larger capacitors reduce output ripple on the negative power supply. Lower ESR capacitors minimize the output ripple and reduce the output impedance of the charge pump.

The LM48860 charge pump design is optimized for 2.2uF, low ESR, ceramic, flying and output capacitors.

### Input Capacitor Value Selection

Amplifying the lowest audio frequencies requires high value input coupling capacitors (C1 and C2 in Figure 1). A high value capacitor 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 150Hz. Applications using speakers with this limited frequency response reap little improvement by using high value input and output capacitors.

As shown in Figure 1, the internal input resistor, $R_i$ and the input capacitors, C1 and C2, produce a -3dB high-pass filter cutoff frequency that is found using Equation 2.

$$f_{i\text{-}3dB} = 1 / 2\pi R_{IN} C \quad \text{(Hz)} \tag{2}$$

The value of $R_{IN}$ can be found in the Electrical Characteristics tables.

## Demonstration Board PCB Layout

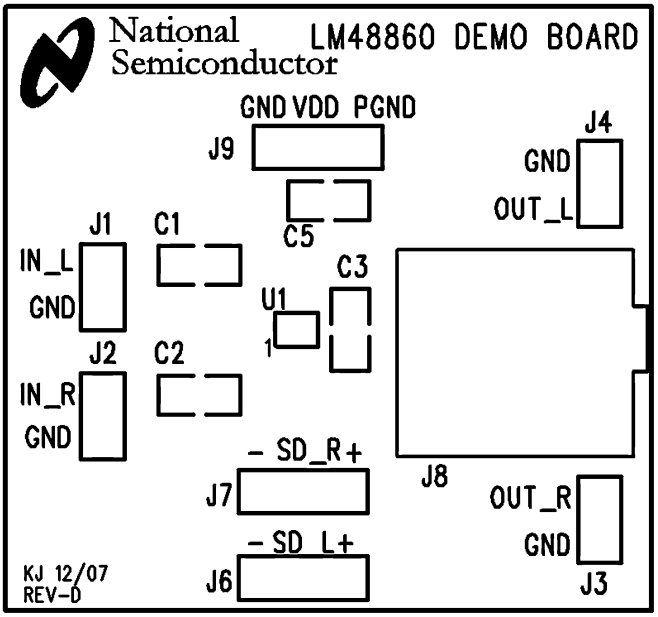


Figure 38. Top Silkscreen

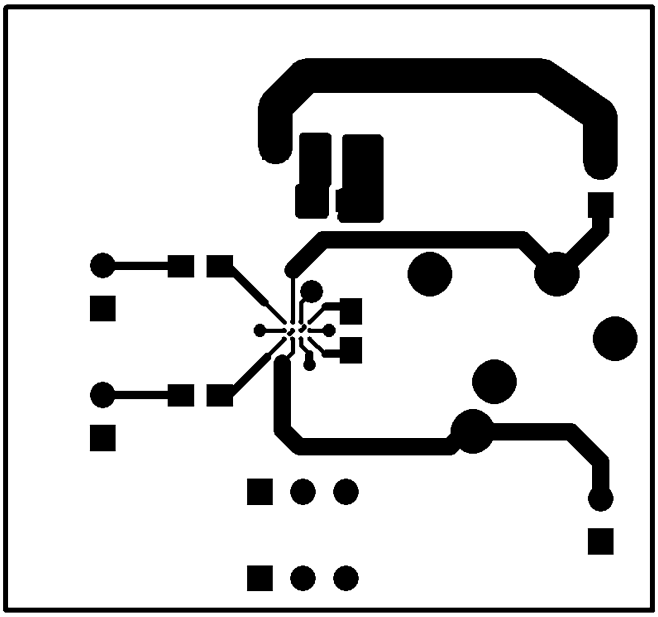

Figure 39. Top Layer

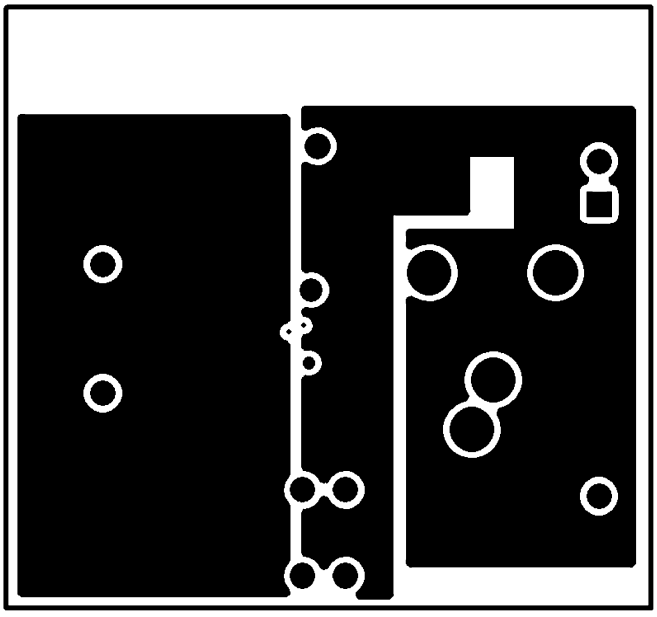

Figure 40. Midlayer 1

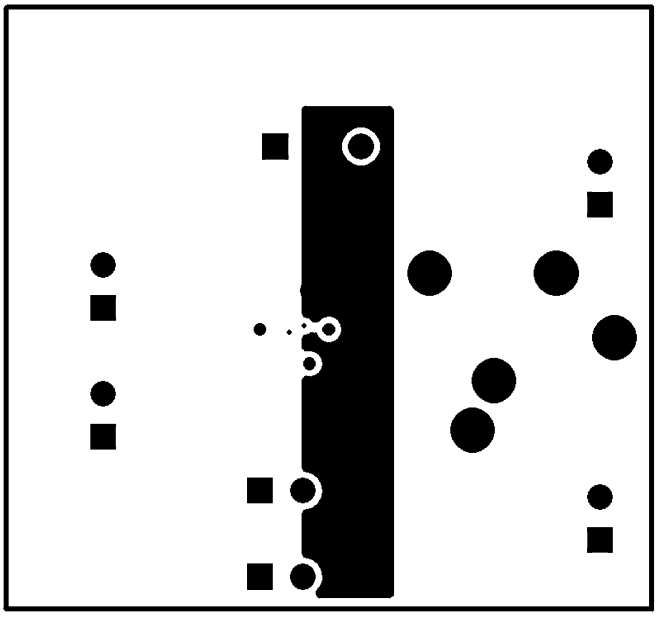

Figure 41. Midlayer 2


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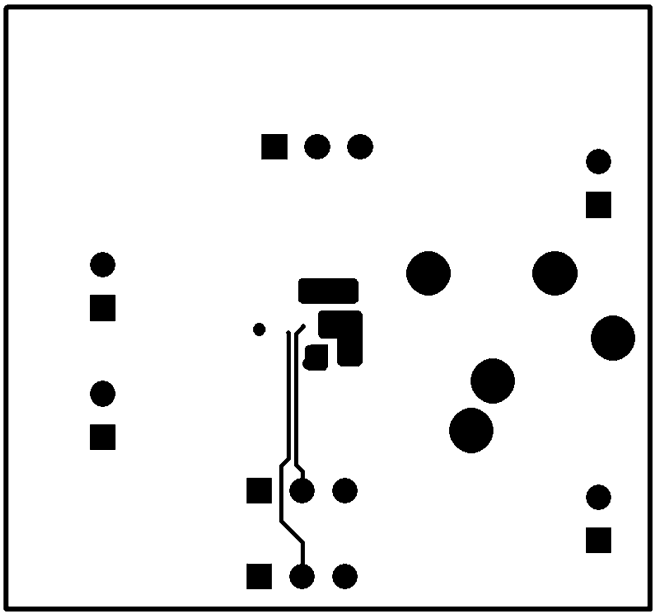

Figure 42. Bottom Layer

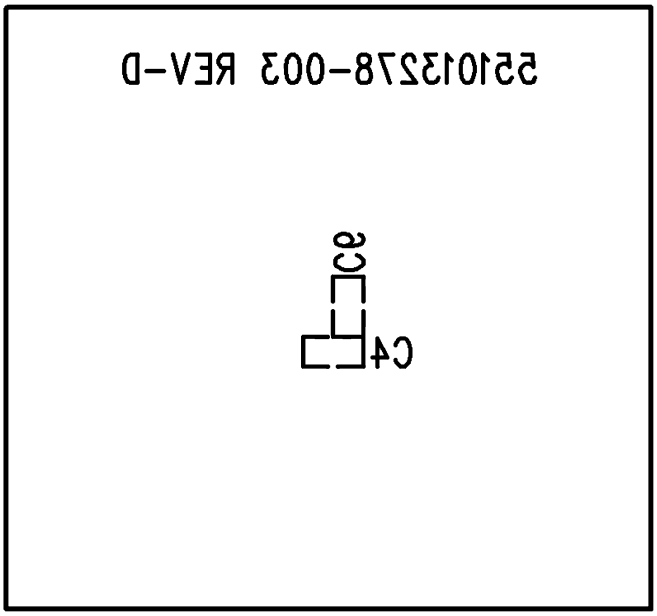


Figure 43. Bottom Silkscreen

## REVISION HISTORY

| Rev | Date | Description |
|---|---|---|
| 1.0 | 01/16/08 | Initial release. |
| 1.01 | 01/29/08 | Text edits. |
| 1.02 | 02/14/08 | Fixed typos (x-axis) on few curves. |
| 1.03 | 10/17/08 | Edited the X1 and X2 limits under the Physical Dimension section. |
| D | 05/02/2013 | Changed layout of National Data Sheet to TI format. |


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## 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LM48860TL/NOPB | ACTIVE | DSBGA | YZR | 12 | 250 | Green (RoHS & no Sb/Br) | SNAGCU | Level-1-260C-UNLIM | -40 to 84 | GJ7 | Samples |
| LM48860TLX/NOPB | ACTIVE | DSBGA | YZR | 12 | 3000 | Green (RoHS & no Sb/Br) | SNAGCU | Level-1-260C-UNLIM | -40 to 84 | GJ7 | 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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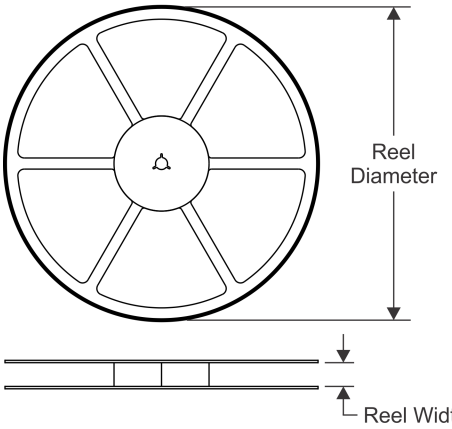
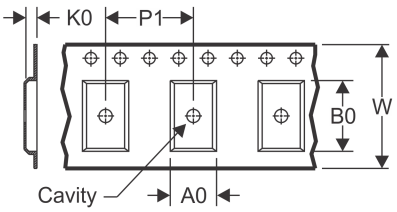
## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

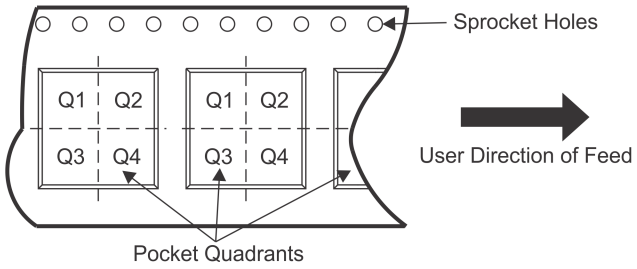



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

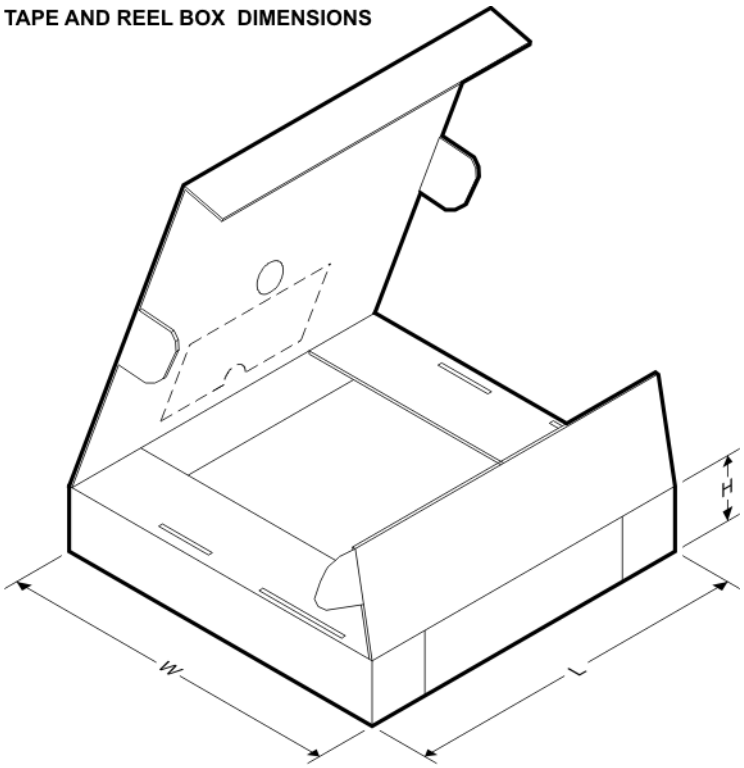
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LM48860TL/NOPB | DSBGA | YZR | 12 | 250 | 178.0 | 8.4 | 1.68 | 2.13 | 0.76 | 4.0 | 8.0 | Q1 |
| LM48860TLX/NOPB | DSBGA | YZR | 12 | 3000 | 178.0 | 8.4 | 1.68 | 2.13 | 0.76 | 4.0 | 8.0 | Q1 |

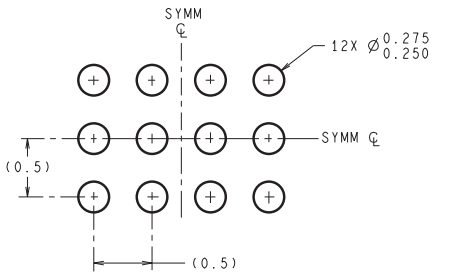
TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

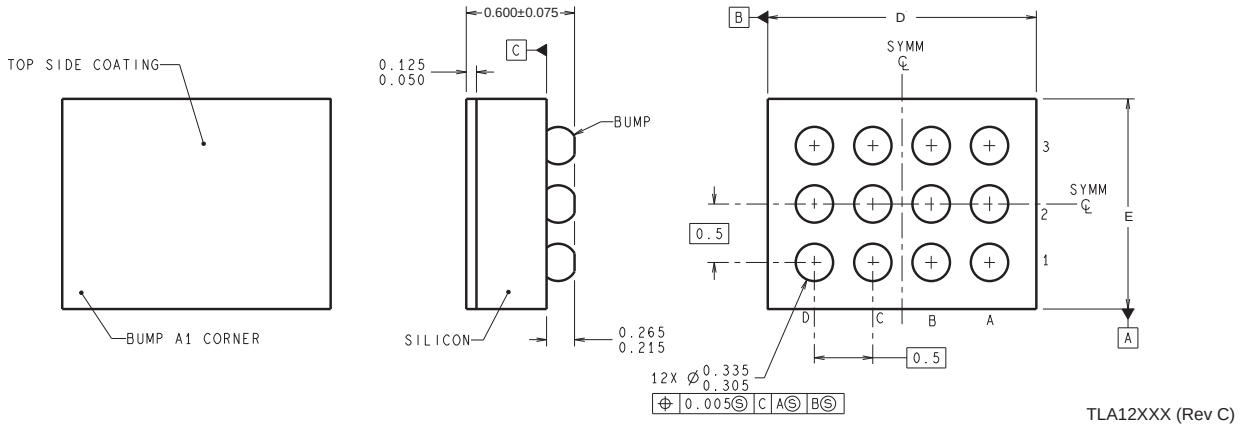
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| LM48860TL/NOPB | DSBGA | YZR | 12 | 250 | 210.0 | 185.0 | 35.0 |
| LM48860TLX/NOPB | DSBGA | YZR | 12 | 3000 | 210.0 | 185.0 | 35.0 |

YZR0012




DIMENSIONS ARE IN MILLIMETERS
DIMENSIONS IN ( ) FOR REFERENCE ONLY

LAND PATTERN RECOMMENDATION




TLA12XXX (Rev C)

D: Max = 2.014 mm, Min =1.954 mm

E: Max = 1.514 mm, Min =1.454 mm

4215049/A 12/12

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.

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