# HWD2119 Audio Power Amplifier

# 350mW Audio Power Amplifier with Shutdown Mode

## General Description

The HWD2119 is a mono bridged power amplifier that is capable of delivering 350mW$_{RMS}$ output power into a 16Ω load or 300mW$_{RMS}$ output power into an 8Ω load with 10% THD+N from a 5V power supply.

The HWD2119 audio power amplifier is designed specifically to provide high quality output power and minimize PCB area with surface mount packaging and a minimal amount of external components. Since the HWD2119 does not require output coupling capacitors, bootstrap capacitors or snubber networks, it is optimally suited for low-power portable applications.

The closed loop response of the unity-gain stable HWD2119 can be configured using external gain-setting resistors. The device is available in LLP, MSOP, and SO package types to suit various applications.

## Key Specifications

- THD+N at 1kHz, 350mW continuous average output power into 16Ω                          10% (max)
- THD+N at 1kHz, 300mW continuous average output power into 8Ω                           10% (max)
- Shutdown Current                          0.7µA (typ)

## Features

- LLP, SOP, and MSOP surface mount packaging.
- Switch on/off click suppression.
- Unity-gain stable.
- Minimum external components.

## Applications

- General purpose audio
- Portable electronic devices
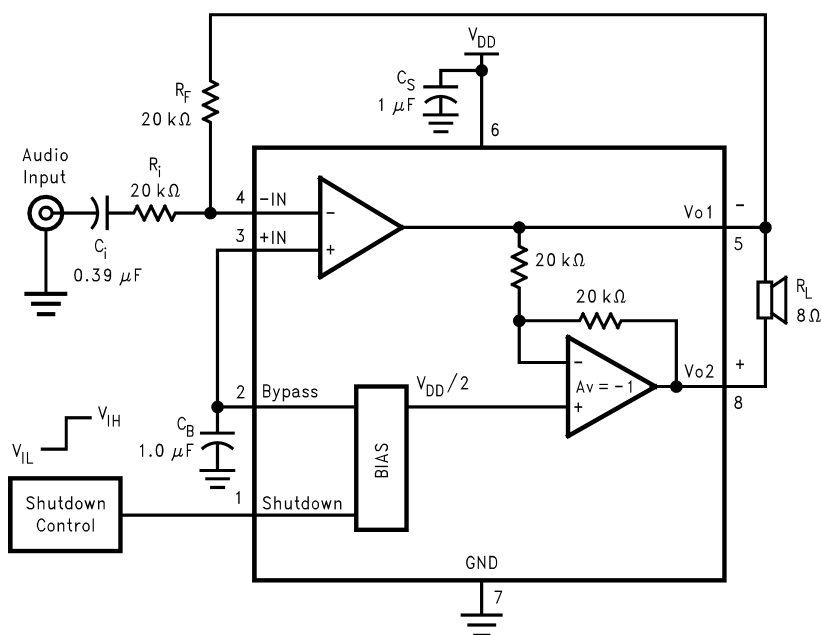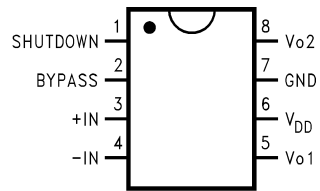- Information Appliances (IA)

## Typical Application



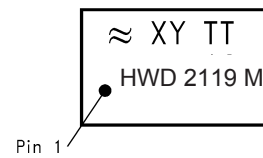**FIGURE 1. Typical Audio Amplifier Application Circuit**
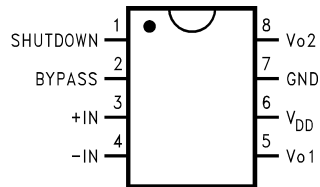
# Connection Diagrams

### Small Outline (SO) Package

| Pin | Signal | | Pin | Signal |
|-----|--------|---|-----|--------|
| 1 | SHUTDOWN | | 8 | Vo2 |
| 2 | BYPASS | | 7 | GND |
| 3 | +IN | | 6 | $V_{DD}$ |
| 4 | −IN | | 5 | Vo1 |

Top View
Order Numer HWD2119M

### Mini Small Outline (MSOP) Package
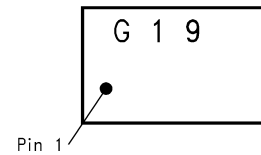
| Pin | Signal | | Pin | Signal |
|-----|--------|---|-----|--------|
| 1 | SHUTDOWN | | 8 | Vo2 |
| 2 | BYPASS | | 7 | GND |
| 3 | +IN | | 6 | $V_{DD}$ |
| 4 | −IN | | 5 | Vo1 |

Top View
Order Number HWD2119MM

### LLP Package

| Pin | Signal | | Pin | Signal |
|-----|--------|---|-----|--------|
| 1 | Shutdown | | 8 | $V_O2$ |
| 2 | Bypass | | 7 | GND |
| 3 | +IN | | 6 | $V_{DD}$ |
| 4 | −IN | | 5 | $V_O1$ |

Top View
Order Number HWD2119LD

### SO Marking

≈ XY TT

HWD 2119 M

Pin 1

Top View
XY - Date Code
TT - Die Traceability
Bottom 2 lines - Part Number

### MSOP Marking

G 1 9

Pin 1

Top View
19 -HWD2119MM

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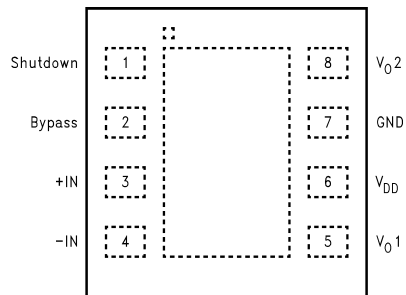
## Absolute Maximum Ratings (Notes 2, 3)

**If Military/Aerospace specified devices are required, please contact the CSMSC 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 ($P_D$) (Note 4) | Internally Limited |
| ESD Susceptibility (Note 5) | 3.5kV |
| ESD Susceptibility (Note 6) | 250V |
| Junction Temperature ($T_J$) | 150°C |
| Soldering Information (Note 1) | |
| Small Outline Package | |
| Vapor Phase (60 seconds) | 215°C |
| Infrared (15 seconds) | 220°C |
| Thermal Resistance | |
| $\theta_{JC}$ (MSOP) | 56°C/W |
| $\theta_{JA}$ (MSOP) | 210°C/W |
| $\theta_{JC}$ (SOP) | 35°C/W |
| $\theta_{JA}$ (SOP) | 170°C/W |
| $\theta_{JA}$ (LLP) | 117°C/W (Note 10) |
| $\theta_{JA}$ (LLP) | 150°C/W (Note 11) |

## Operating Ratings (Notes 2, 3)

| | |
|---|---|
| Temperature Range | |
| $T_{MIN} \leq T_A \leq T_{MAX}$ | −40°C $\leq T_A \leq$ 85°C |
| Supply Voltage | 2.0V $\leq V_{CC} \leq$ 5.5V |

## Electrical Characteristics $V_{DD}$ = 5V (Notes 2, 3)

The following specifications apply for $V_{DD}$ = 5V, $R_L$ = 16Ω unless otherwise stated. Limits apply for $T_A$ = 25°C.

| Symbol | Parameter | Conditions | HWD2119 | | Units (Limits) |
|---|---|---|---|---|---|
| | | | Typical | Limit | |
| | | | (Note 7) | (Notes 8, 9) | |
| $I_{DD}$ | Quiescent Power Supply Current | $V_{IN}$ = 0V, $I_o$ = 0A | 1.5 | 3.0 | mA (max) |
| $I_{SD}$ | Shutdown Current | $V_{PIN1}$ = $V_{DD}$ (Note 12) | 1.0 | 5.0 | µA (max) |
| $V_{SDIH}$ | Shutdown Voltage Input High | | | 4.0 | V (min) |
| $V_{SDIL}$ | Shutdown Voltage Input Low | | | 1.0 | V (max) |
| $V_{OS}$ | Output Offset Voltage | $V_{IN}$ = 0V | 5 | 50 | mV (max) |
| $P_O$ | Output Power | THD = 10%, $f_{IN}$ = 1kHz | 350 | | mW |
| | | THD = 10%, $f_{IN}$ = 1kHz, $R_L$ = 8Ω | 300 | | mW |
| THD+N | Total Harmonic Distortion + Noise | $P_O$ = 270mW$_{RMS}$, $A_{VD}$ = 2, $f_{IN}$ = 1kHz | 1 | | % |

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

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

| Symbol | Parameter | Conditions | HWD2119 | | Units (Limits) |
|---|---|---|---|---|---|
| | | | Typical | Limit | |
| | | | (Note 7) | (Notes 8, 9) | |
| $I_{DD}$ | Quiescent Power Supply Current | $V_{IN}$ = 0V, $I_o$ = 0A | 1.0 | 3.0 | mA (max) |
| $I_{SD}$ | Shutdown Current | $V_{PIN1}$ = $V_{DD}$ (Note 12) | 0.7 | 5.0 | µA (max) |
| $V_{SDIH}$ | Shutdown Voltage Input High | | | 2.4 | V (min) |
| $V_{SDIL}$ | Shutdown Voltage Input Low | | | 0.6 | V (max) |
| $V_{OS}$ | Output Offset Voltage | $V_{IN}$ = 0V | 5 | 50 | mV |
| $P_O$ | Output Power | THD = 10%, $f_{IN}$ = 1kHz | 110 | | mW |
| | | THD = 10%, $f_{IN}$ = 1kHz, $R_L$ = 8Ω | 90 | | mW |
| THD+N | Total Harmonic Distortion + Noise | $P_O$ = 80mW$_{RMS}$, $A_{VD}$ = 2, $f_{IN}$ = 1kHz | 1 | | % |

# Electrical Characteristics V$_{DD}$ = 3V (Notes 2, 3)

The following specifications apply for V$_{DD}$ = 3V and R$_L$ = 16Ω load unless otherwise stated. Limits apply to T$_A$ = 25˚C. (Continued)

**Note 1:** See AN-450 'Surface Mounting and their Effects on Product Reliability' for other methods of soldering surface mount devices.

**Note 2:** All voltages are measured with respect to the ground pin, unless otherwise specified.

**Note 3:** *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur. *Operating Ratings* indicate conditions for which the device is functional, but do not guarantee specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters where no limit is given. However, the typical value is a good indication of device's performance.

**Note 4:** 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$_A$)/θ$_{JA}$. For the HWD2119, T$_{JMAX}$ = 150˚C and the typical junction-to-ambient thermal resistance (θ$_{JA}$) when board mounted is 210˚C/W for the MSOP package and 170˚C/W for the SOP package.

**Note 5:** Human body model, 100pF discharged through a 1.5 kΩ resistor.

**Note 6:** Machine Model, 220pF−240pF capacitor is discharged through all pins.

**Note 7:** Typical specifications are specified at 25˚C and represent the parametric norm.

**Note 8:** Tested limits are guaranteed to National's AOQL (Average Outgoing Quality Level).

**Note 9:** Datasheet min/max specification limits are guaranteed by designs, test, or statistical analysis.

**Note 10:** The given θ$_{JA}$ is for an HWD2119 package in an LDA08B with the Exposed-DAP soldered to a printed circuit board copper pad with an area equivalent to that of the Exposed-DAP itself. The Exposed-DAP of the LDA08B package should be electrically connected to GND or an electrically isolated copper area.

**Note 11:** The given θ$_{JA}$ is for an HWD2119 package in an LDA08B with the Exposed-DAP not soldered to any printed circuit board copper.

**Note 12:** The shutdown pin (pin1) should be driven as close as possible to V$_{DD}$ for minimum current in Shutdown Mode.

# External Components Description (*Figure 1*)

| Components | | Functional Description |
|---|---|---|
| 1. | R$_i$ | Combined with R$_f$, this inverting input resistor sets the closed-loop gain. R$_i$ also forms a high pass filter with C$_i$ at f$_c$ = 1/(2πR$_i$C$_i$). |
| 2. | C$_i$ | This input coupling capacitor blocks DC voltage at the amplifier's terminals. Combined with R$_i$, it creates a high pass filter with R$_i$ at f$_c$ = 1/(2πR$_i$C$_i$). Refer to the section, **Proper Selection of External Components** for an explanation of how to determine the value of C$_i$. |
| 3. | R$_f$ | Combined with R$_i$, this is the feedback resistor that sets the closed-loop gain: A$_v$ = 2(R$_F$/R$_i$). |
| 4. | C$_S$ | This is the power supply bypass capacitor that filters the voltage applied to the power supply pin. Refer to the **Application Information** section for proper placement and selection of C$_s$. |
| 5. | C$_B$ | This is the bypass pin capacitor that filters the voltage at the BYPASS pin. Refer to the section, **Proper Selection of External Components**, for information concerning proper placement and selection of C$_B$. |

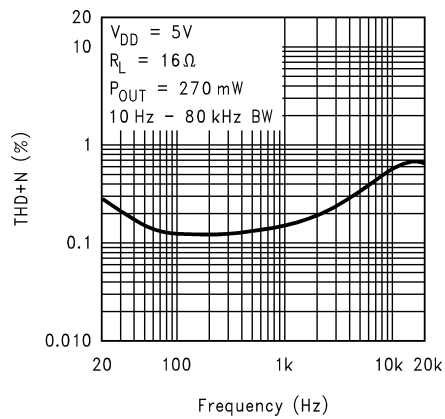# Typical Performance Characteristics
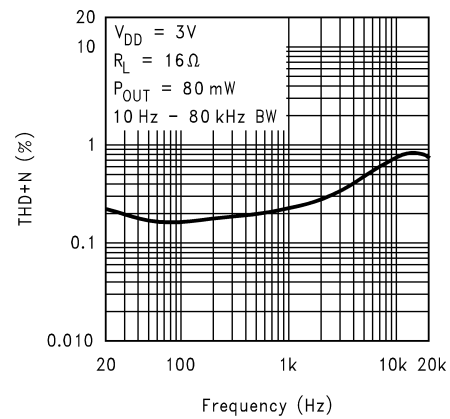
**THD+N vs Frequency**
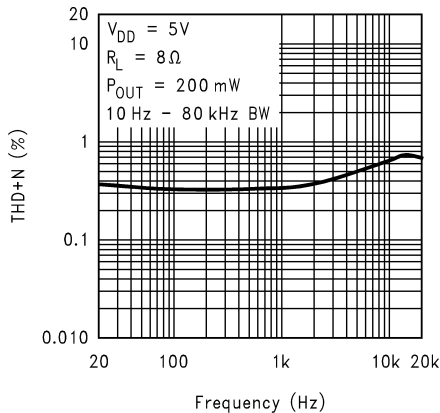


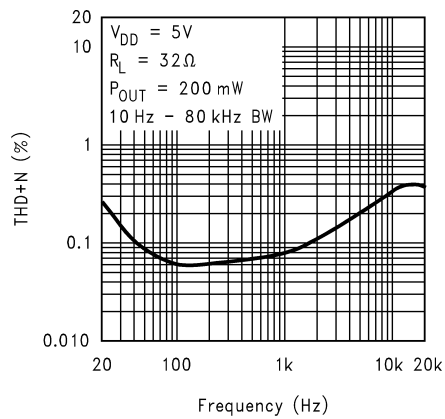**THD+N vs Frequency**
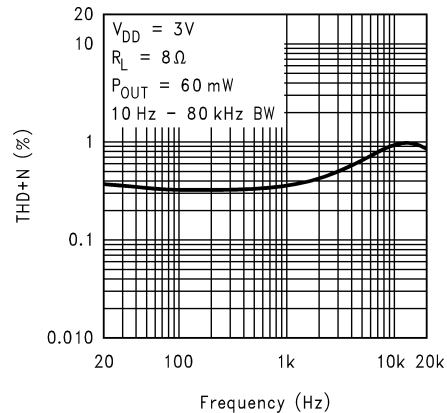
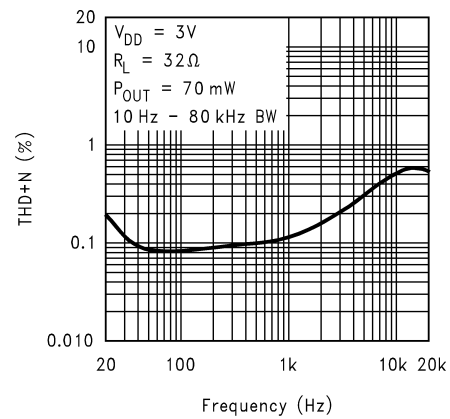# Typical Performance Characteristics (Continued)

**THD+N vs Frequency**



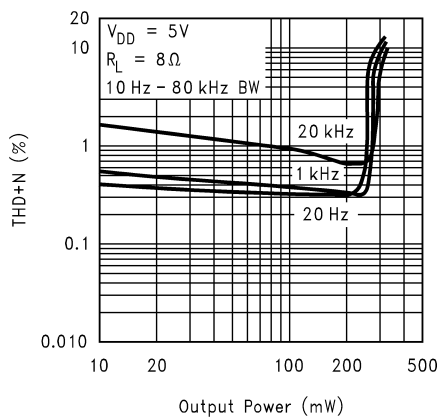$V_{DD}$ = 5V
$R_L$ = 16 Ω
$P_{OUT}$ = 270 mW
10 Hz − 80 kHz BW

**THD+N vs Frequency**



$V_{DD}$ = 3V
$R_L$ = 16 Ω
$P_{OUT}$ = 80 mW
10 Hz − 80 kHz BW

**THD+N vs Frequency**



$V_{DD}$ = 5V
$R_L$ = 32 Ω
$P_{OUT}$ = 200 mW
10 Hz − 80 kHz BW

**THD+N vs Frequency**



$V_{DD}$ = 3V
$R_L$ = 32 Ω
$P_{OUT}$ = 70 mW
10 Hz − 80 kHz BW

**THD+N vs Output Power**



$V_{DD}$ = 5V
$R_L$ = 8 Ω
10 Hz − 80 kHz BW
20 kHz
1 kHz
20 Hz

**THD+N vs Output Power**



$V_{DD}$ = 3V
$R_L$ = 8 Ω
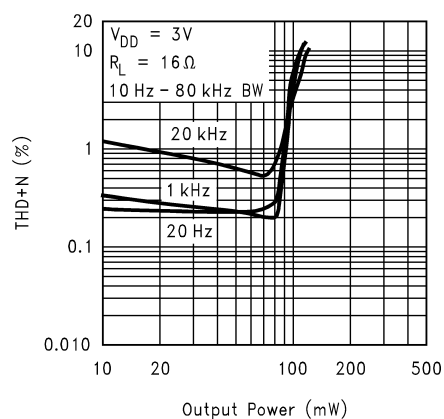10 Hz − 80 kHz BW
20 kHz
1 kHz
20 Hz
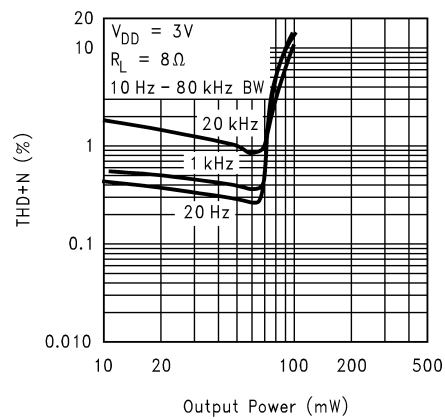
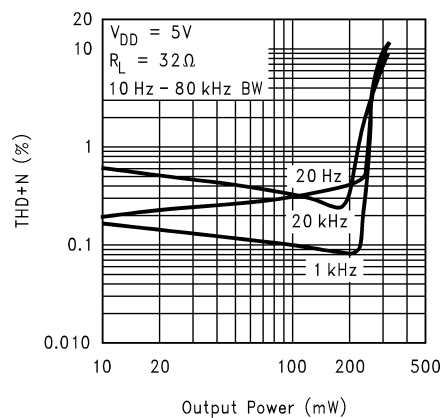# Typical Performance Characteristics (Continued)

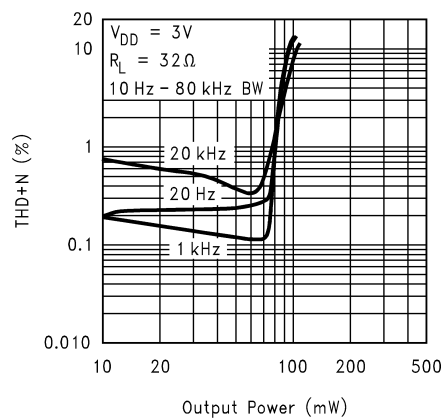**THD+N vs Output Power**
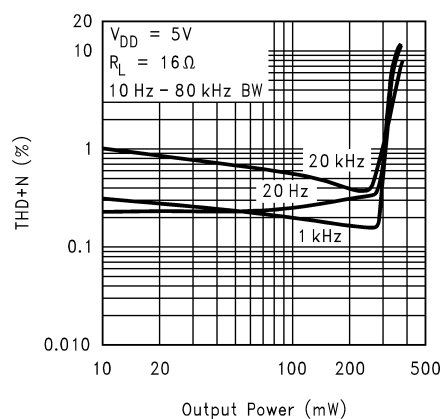


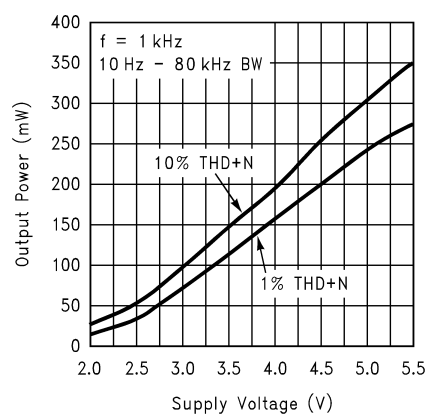**THD+N vs Output Power**
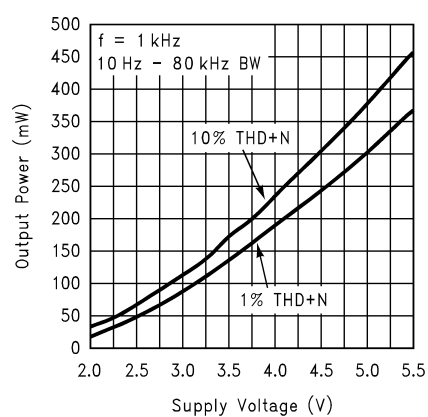


**THD+N vs Output Power**



**THD+N vs Output Power**



**Output Power vs Supply Voltage**
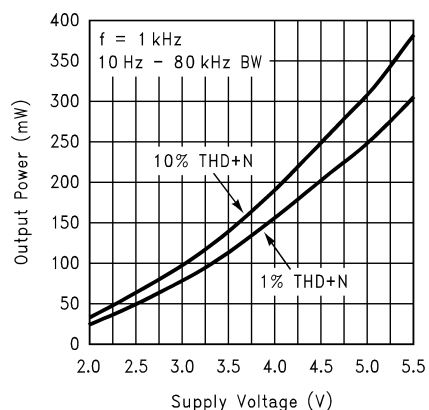**$R_L$ = 8$\Omega$**



**Output Power vs Supply Voltage**
**$R_L$ = 16$\Omega$**



5

# Typical Performance Characteristics (Continued)

**Output Power vs Supply Voltage**
$R_L = 32\Omega$

f = 1 kHz
10 Hz – 80 kHz BW
10% THD+N
1% THD+N

(Output Power (mW) vs Supply Voltage (V))

**Output Power vs Load Resistance**
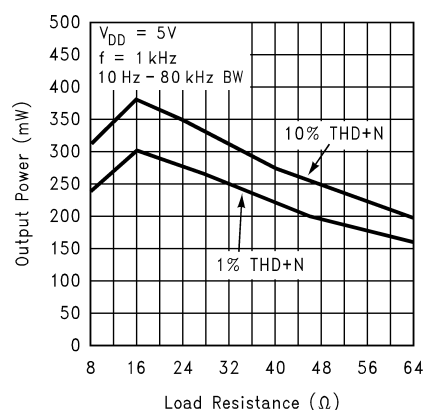
$V_{DD}$ = 5V
f = 1 kHz
10 Hz – 80 kHz BW
10% THD+N
1% THD+N

(Output Power (mW) vs Load Resistance ($\Omega$))

**Power Dissipation vs
Output Power
$V_{DD}$ = 5V**

$V_{DD}$ = 5V
f = 1 kHz
THD+N < 10%
10 Hz – 80 kHz BW
$R_L$ = 8$\Omega$
$R_L$ = 16$\Omega$
$R_L$ = 32$\Omega$

(Power Dissipation (mW) vs Output Power (mW))

**Power Dissipation vs
Output Power
$V_{DD}$ = 3V**

$V_{DD}$ = 3V
f = 1 kHz
THD+N < 10%
10 Hz – 80 kHz BW
$R_L$ = 8$\Omega$
$R_L$ = 16$\Omega$
$R_L$ = 32$\Omega$

(Power Dissipation (mW) vs Output Power (W))

**Power Derating Curves**

Package M08A
Package MUA08A

(Power Dissipation (mW) vs Ambient Temperature (°C))
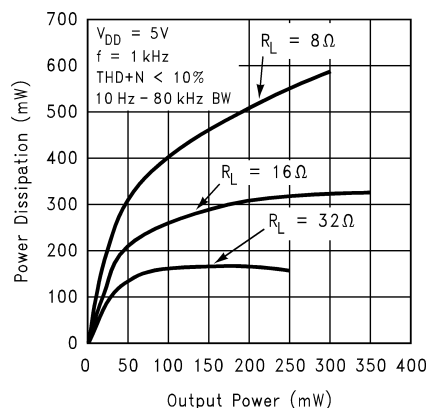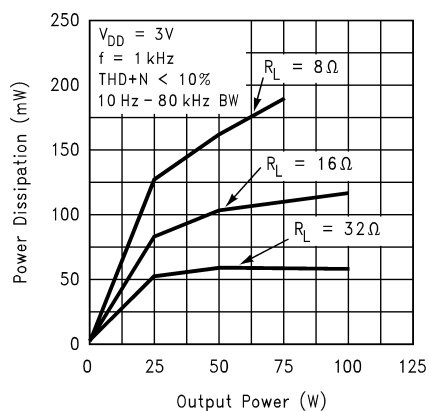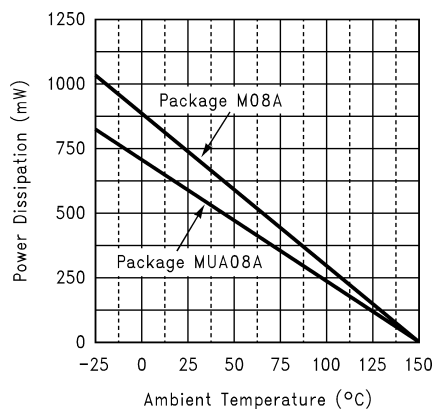
**Frequency Response vs
Input Capacitor Size**

1 $\mu$F tant
0.33 $\mu$F ceramic

(Output Level (dB) vs Frequency (Hz))

6
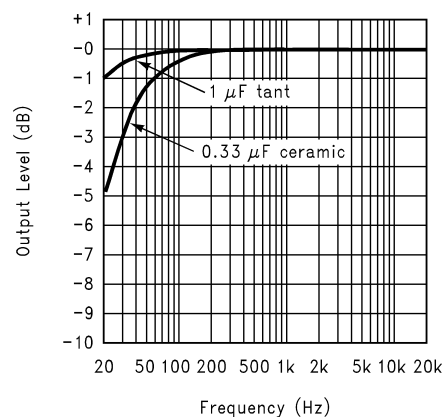
# Typical Performance Characteristics (Continued)

**Supply Current vs**
**Supply Voltage**
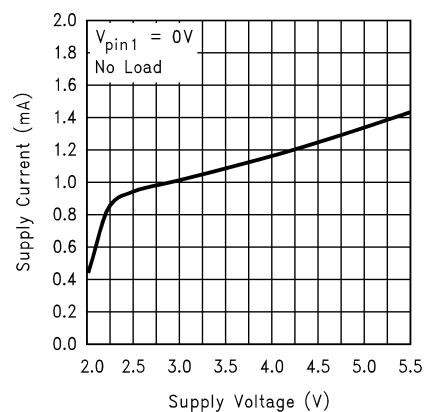
# Application Information

## BRIDGE CONFIGURATION EXPLANATION

As shown in *Figure 1*, the HWD2119 consist of two operational amplifiers. External resistors, $R_i$ and $R_F$ set the closed-loop gain of the first amplifier (and the amplifier overall), whereas two internal 20kΩ resistors set the second amplifier's gain at -1. The HWD2119 is typically used to drive a speaker connected between the two amplifier outputs.

*Figure 1* shows that the output of Amp1 servers as the input to Amp2, which 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 $V_{01}$ and $V_{02}$ and driven differentially (commonly referred to as 'bridge mode'). This results in a differential gain of

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

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

Another advantage of the differential bridge output is no net DC voltage across the load. This results from biasing $V_{01}$ and $V_{02}$ 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. The current flow created by the half-supply bias voltage 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 bridged or single-ended amplifier. Equation (2) states the maximum power dissipation point for a single-ended amplifier operating at a given supply voltage and driving a specified load.

$$P_{DMAX} = (V_{DD})^2 /(2\pi^2 R_L ) \text{ (W) Single-ended} \qquad (2)$$

However, a direct consequence of the increased power delivered to the load by a bridged amplifier is an increase in the internal power dissipation point for a bridge amplifier operating at the same given conditions. Equation (3) states the maximum power dissipation point for a bridged amplifier operating at a given supply voltage and driving a specified load.

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

The HWD2119 has two operational amplifiers in one package and the maximum internal power dissipation is four times that of a single-ended amplifier. However, even with this substantial increase in power dissipation, the HWD2119 does not require heatsinking. From Equation (3), assuming a 5V power supply and an 8Ω load, the maximum power dissipation point is 633mW. The maximum power dissipation point obtained from Equation (3) must not exceed the power dissipation predicted by Equation (4):

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

For the micro MUA08A package, $\theta_{JA} = 210°C/W$, for the M08A package, $\theta_{JA} = 170°C/W$ , and $T_{JMAX} = 150°C$ for the HWD2119. For a given ambient temperature $T_A$, Equation (4) can be used to find the maximum internal power dissipation supported by the IC packaging. If the result of Equation (3) is greater than the result of Equation (4), then decrease the supply voltage, increase the load impedance, or reduce the ambient temperature. For a typical application using the M08A packaged HWD2119 with a 5V power supply and an 8Ω load, the maximum ambient temperature that does not violate the maximum junction temperature is approximately 42°C. If a MUA08A packaged part is used instead with the same supply voltage and load, the maximum ambient temperature is 17°C. In both cases, it is assumed that a device is a surface mount part operating around the maximum power dissipation point. The assumption that the device is operating around the maximum power dissipation point is incorrect for an 8Ω load. The maximum power dissipation point occurs when the output power is equal to the maximum power dissipation or 50% efficiency. The HWD2119 is not capable of the output power level (633mW) required to operate at the maximum power dissipation point for an 8Ω load. To find the maximum power dissipation, the graph **Power Dissipation vs. Output Power** must be used. From the graph, the maximum power dissipation for an 8Ω load and a 5V supply is approximately 575mW. Substituting this value back into equation (4) for $P_{DMAX}$ and using $\theta_{JA} = 210°C/W$ for the MUA08A package, the maximum ambient temperature is calculated to be 29°C. Using $\theta_{JA} = 170°C/W$ for the M08A package, the maximum ambient temperature is 52°C. Refer to the **Typical Performance Characteristics** curves for power dissipation information for lower output powers and maximum power dissipation for each package at a given ambient temperature.

## POWER SUPPLY BYPASSING

As with any power amplifier, proper supply bypassing is critical for low noise performance and high power supply rejection. The capacitors connected to the bypass and power supply pins should be placed as close to the HWD2119 as possible. The capacitor connected between the bypass pin and ground improves the internal bias voltage's stability, producing improved PSRR. The improvements to PSRR increase as the bypass pin capacitor value increases. Typical applications employ a 5V regulator with 10µF and 0.1µF filter capacitors that aid in supply stability. Their presence, however, does not eliminate the need for bypassing the supply nodes of the HWD2119. The selection of bypass capacitor values, especially $C_B$ , depends on desired PSRR requirements, click and pop performance as explained in the section, **Proper Selection of External Components,** as well as system cost and size constraints.

## SHUTDOWN FUNCTION

The voltage applied to the HWD2119's SHUTDOWN pin controls the shutdown function. Activate micro-power shutdown by applying $V_{DD}$ to the SHUTDOWN pin. When active, the HWD2119's micro-power shutdown feature turns off the amplifier's bias circuitry, reducing the supply current. The logic threshold is typically $1/2V_{DD}$. The low 0.7µA 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. Avoid intermittent or unexpected micro-power shutdown by ensuring that the SHUTDOWN pin is not left floating but connected to either $V_{DD}$ or GND.

## Application Information (Continued)

There are a few ways to activate micro-power shutdown. These included using a single-pole, single-throw switch, a microcontroller, or a microprocessor. When using a switch, connect an external 10kΩ to 100kΩ 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 pull-up resistor

### PROPER SELECTION OF EXTERNAL COMPONENTS

Optimizing the HWD2119's performance requires properly selecting external components. Though the HWD2119 operates well when using external components with wide tolerances, best performance is achieved by optimizing component values.

The HWD2119 is unity gain stable, giving the 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 demands 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.

Another important consideration is the amplifier's close-loop bandwidth. To a large extent, the bandwidth is dictated by the choice of external components shown in *Figure 1*. The input coupling capacitor, $C_i$, forms a first order high pass filter that limits low frequency response. This value should be chosen based on needed frequency response for a few distinct reasons discussed below

### Input Capacitor Value Selection

Amplifying the lowest audio frequencies requires a high value input coupling capacitor ($C_i$ in *Figure 1*). A high value capacitor can be expensive and may compromise space efficiency in portable designs. In many cases the speakers used in portable systems, whether internal or external, have little ability to reproduce signals below 150Hz. Applications using speakers with limited frequency response reap little improvement by using a large input capacitor.

Besides affecting system cost and size, $C_i$ has an effect on the HWD2119'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 value. Higher value capacitors need more time to reach a quiescent DC voltage (usually $1/2$ $V_{DD}$) when charged with a fixed current. The amplifier's output charges the input capacitor through the feedback resistor, $R_F$. Thus, selecting an input capacitor value that is no higher than necessary to meet the desired -3dB frequency can minimize pops.

As shown in *Figure 1*, the input resistor ($R_i$) and the input capacitor, $C_i$ produce a -3dB high pass filter cutoff frequency that is found using Equation (5).

$$f_{-3dB} = 1/(2\ \pi R_i C_i)\ (Hz) \qquad (5)$$

As an example when using a speaker with a low frequency limit of 150Hz, $C_i$, using Equation (5) is 0.063µF. The 0.39µF $C_i$ shown in *Figure 1* allows the HWD2119 to drive a high efficiency, full range speaker whose response extends down to 20Hz.

Besides optimizing the input capacitor value, the bypass capacitor value, $C_B$ requires careful consideration. The bypass capacitor's value is the most critical to minimizing turn-on pops because it determines how fast the HWD2119 turns on. The slower the HWD2119's outputs ramp to their quiescent DC voltage (nominally $1/2V_{DD}$), the smaller the turn-on pop. While the device will function properly (no oscillations or motorboating), with $C_B$ less than 1.0µF, the device will be much more susceptible to turn-on clicks and pops. Thus, a value of $C_B$ equal to or greater than 1.0µF is recommended in all but the most cost sensitive designs.

### Bypass Capacitor Value Selection

Besides minimizing the input capacitor size, careful consideration should be paid to the value of $C_B$, the capacitor connected to the BYPASS pin. Since $C_B$ determines how fast the HWD2119 settles to quiescent operation, its value is critical when minimizing turn-on pops. The slower the HWD2119's outputs ramp to their quiescent DC voltage (nominally $1/2V_{DD}$), the smaller the turn-on pop. Choosing $C_B$ equal to 1.0µF along with a small value of $C_i$ (in the range of 0.1µF to 0.39µF) produces a click-less and pop-less shutdown function. As discussed above, choosing $C_i$ no larger than necessary for the desired bandwidth helps minimize clicks and pops.

### Optimizing Click and Pop Reduction Performance

The HWD2119 contains circuitry that minimizes turn-on and shutdown transients or 'clicks and pops'. For this discussion, turn on refers to either applying the power or supply voltage or when the shutdown mode is deactivated. While the power supply is ramping to it's final value, the HWD2119's internal amplifiers are configured as unity gain buffers. An internal current source charges the voltage of the bypass capacitor, $C_B$, connected to the BYPASS pin in a controlled, linear manner. Ideally, the input and outputs track the voltage charging on the bypass capacitor. The gain of the internal amplifiers remains unity until the bypass capacitor is fully charged to $1/2V_{DD}$. As soon as the voltage on the bypass capacitor is stable, the device becomes fully operational. Although the BYPASS pin current cannot be modified, changing the size of the bypass capacitor, $C_B$, alters the device's turn-on time and 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 (Ton) increases. There is a linear relationship between the size of $C_B$ and the turn on time. Below are some typical turn-on times for various values of $C_B$:

| $C_B$ | $T_{ON}$ |
|---|---|
| 0.01µF | 20ms |
| 0.1µF | 200ms |
| 0.22µF | 440ms |
| 0.47µF | 940ms |
| 1.0µF | 2S |

## Application Information (Continued)

In order to eliminate 'clicks and pops', all capacitors must be discharged before turn-on. Rapidly switching $V_{DD}$ may not allow the capacitors to fully discharge, which may cause 'clicks and pops'.

### AUDIO POWER AMPLIFIER DESIGN EXAMPLE

**The following are the desired operational parameters:**

Given:

| | |
|---|---|
| Power Output | 100mW |
| Load Impedance | 16Ω |
| Input Level | 1Vrms (max) |
| Input Impedance | 20kΩ |
| Bandwidth | 100Hz–20kHz ± 0.25dB |

The design begins by specifying the minimum supply voltage necessary to obtain the specified output power. To find this minimum supply voltage, use the **Output Power vs. Supply Voltage** graph in the **Typical Performance Characteristics** section. From the graph for a 16Ω load, (graphs are for 8Ω, 16Ω, and 32Ω loads) the supply voltage for 100mW of output power with 1% THD+N is approximately 3.15 volts.

Additional supply voltage creates the benefit of increased headroom that allows the HWD2119 to reproduce peaks in excess of 100mW without output signal clipping or audible distortion. The choice of supply voltage must also not create a situation that violates maximum dissipation as explained above in the **Power Dissipation** section. For example, if a 3.3V supply is chosen for extra headroom then according to Equation (3) the maximum power dissipation point with a 16Ω load is 138mW. Using Equation (4) the maximum ambient temperature is 121°C for the MUA08A package and 126°C for the M08A package.

After satisfying the HWD2119's power dissipation requirements, the minimum differential gain is found using Equation (6).

$$A_{VD} \geq \sqrt{(P_O R_L)}/(V_{IN}) = V_{orms}/V_{inrms} \tag{6}$$

Thus a minimum gain of 1.27 V/V allows the HWD2119 to reach full output swing and maintain low noise and THD+N performance. For this example, let $A_{VD} = 1.27$. The amplifier's overall gain is set using the input ($R_i$) and feedback ($R_F$) resistors. With the desired input impedance set to 20kΩ, the feedback resistor is found using Equation (7).

$$R_F/R_i = A_{VD}/2 \text{ (V/V)} \tag{7}$$

The value of $R_F$ is 13kΩ.

The last step in this design example is setting the amplifier's -3dB 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 with in the ±0.25dB desired limit.

The results are:

$$f_L = 100Hz/5 = 20Hz$$
$$f_H = 20 \text{ kHz}*5 = 100kHz$$

As mentioned in the **External Components** section, $R_i$ and $C_i$ create a high pass filter that sets the amplifier's lower band pass frequency limit. Find the coupling capacitor's value using Equation (8).

$$C_i \geq 1/(2\pi R_i f_c) \text{ (F)} \tag{8}$$

$C_i \geq 0.398\mu F$, a standard value of 0.39μF will be used. The product of the desired high frequency cutoff (100kHz in this example) and the differential gain, $A_{VD}$, determines the upper pass band response limit. With $A_{VD} = 1.27$ and $f_H = 100kHz$, the closed-loop gain bandwidth product (GBWP) is 127kHz. This is less than the HWD2119's 900kHz GBWP. With this margin the amplifier can be used in designs that require more differential gain while avoiding performance restricting bandwidth limitations.

# Application Information (Continued)
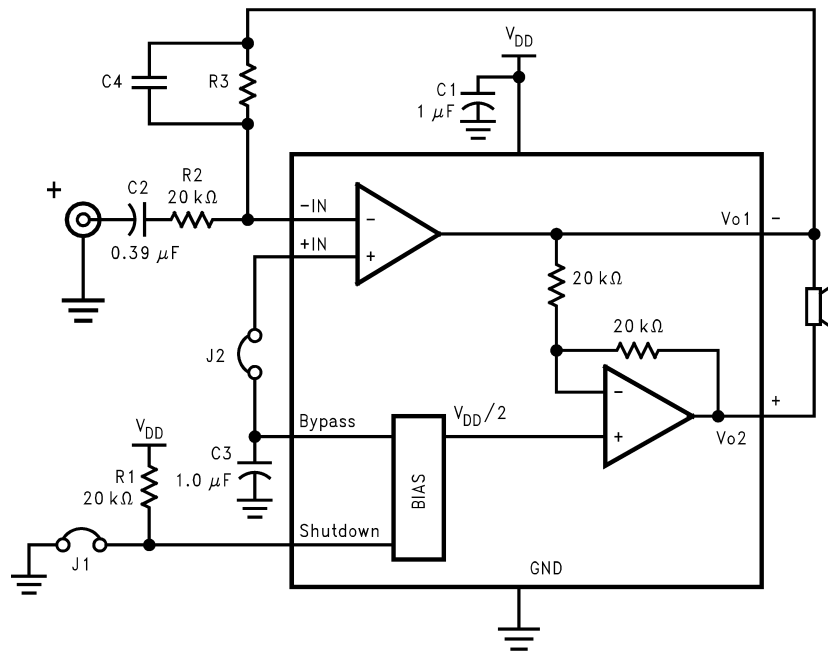
**HIGHER GAIN AUDIO AMPLIFIER**



**Figure 2**

The HWD2119 is unity-gain stable and requires no external components besides gain-setting resistors, an input coupling capacitor, and proper supply bypassing in the typical application. However, if a closed-loop differential gain of greater than 10 is required, a feedback capacitor ($C_4$) may be needed as shown in Figure 2 to bandwidth limit the amplifier. This feedback capacitor creates a low pass filter that eliminates possible high frequency oscillations. Care should be taken when calculating the -3dB frequency in that an incorrect combination of $R_3$ and $C_4$ will cause rolloff before 20kHz. A typical combination of feedback resistor and capacitor that will not produce audio band high frequency rolloff is $R_3 = 20k\Omega$ and $C_4 = 25pF$. These components result in a -3dB point of approximately 320 kHz. It is not recommended that the feedback resistor and capacitor be used to implement a band limiting filter below 100kHz.

# Application Information (Continued)
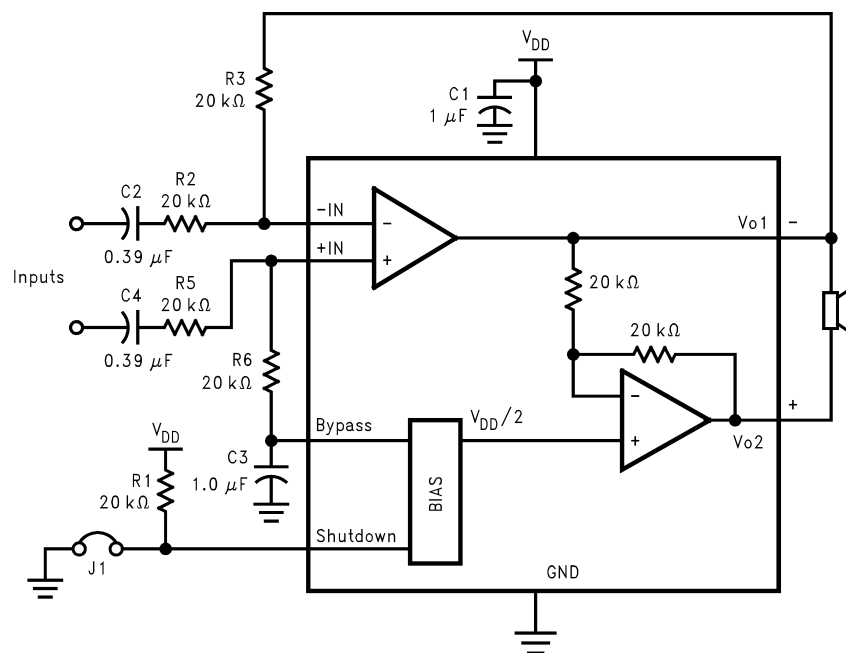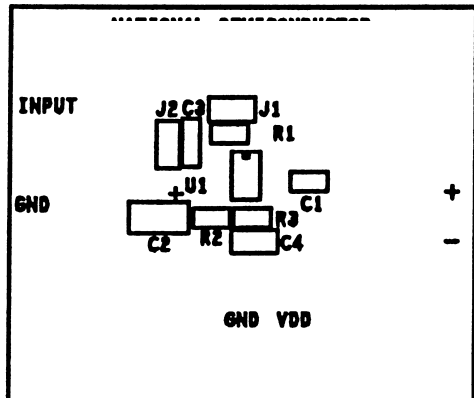
**DIFFERENTIAL AMPLIFIER CONFIGURATION FOR HWD2119**



**Figure 3**

# Application Information (Continued)

**REFERENCE DESIGN BOARD and PCB LAYOUT GUIDELINES**



**Figure 4**

# Application Information
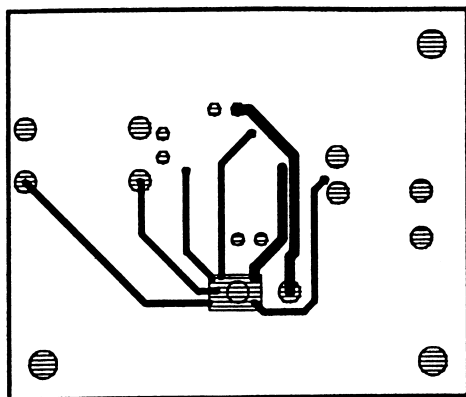
**HWD2119 SO DEMO BOARD ARTWORK**
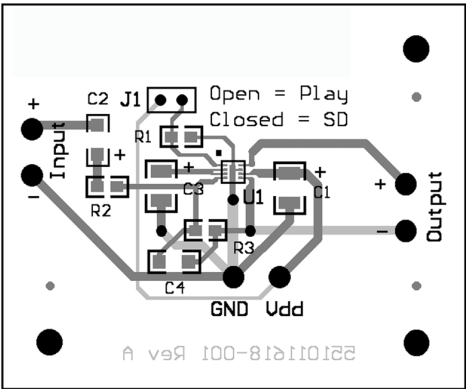
**Silk Screen**
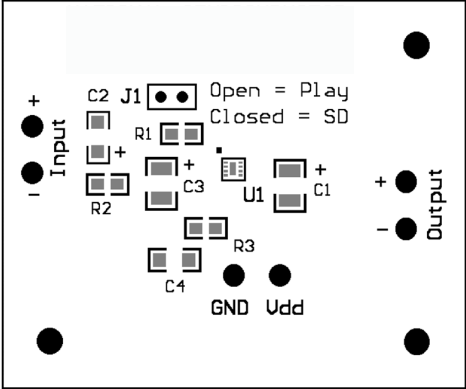


**Top Layer**
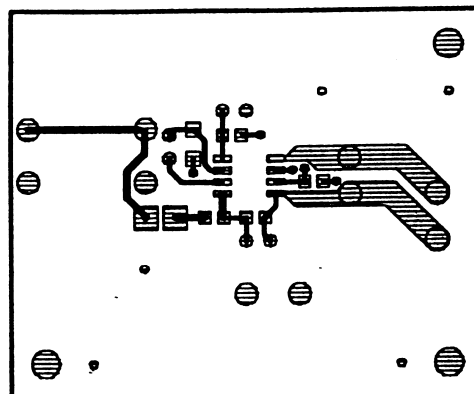


**Bottom Layer**

# Application Information (Continued)

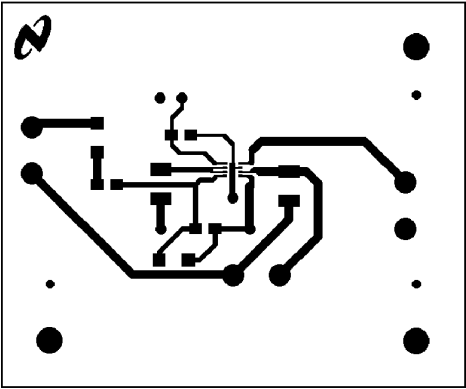## HWD2119 LD DEMO BOARD ARTWORK

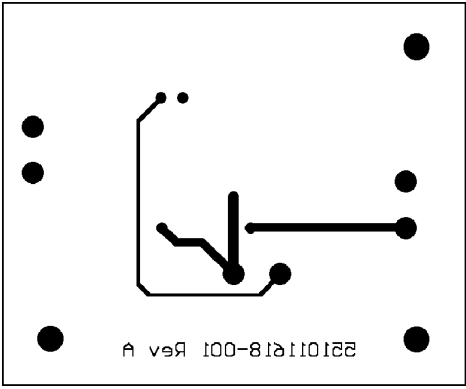### Composite View



### Silk Screen



### Top Layer



### Bottom Layer

# Application Information (Continued)

## Mono HWD2119 Reference Design Boards
## Bill of Material for all Demo Boards

| Item | Part Number | Part Description | Qty | Ref Designator |
|---|---|---|---|---|
| 1 | 551011208-001 | HWD2119 Mono Reference Design Board | 1 | |
| 10 | 482911183-001 | HWD2119 Audio AMP | 1 | U1 |
| 20 | 151911207-001 | Tant Cap 1uF 16V 10 | 1 | C1 |
| 21 | 151911207-002 | Cer Cap 0.39uF 50V Z5U 20% 1210 | 1 | C2 |
| 25 | 152911207-001 | Tant Cap 1uF 16V 10 | 1 | C3 |
| 30 | 472911207-001 | Res 20K Ohm 1/10W 5 | 3 | R1, R2, R3 |
| 35 | 210007039-002 | Jumper Header Vertical Mount 2X1 0.100 | 2 | J1, J2 |

**PCB LAYOUT GUIDELINES**

This section provides practical guidelines for mixed signal PCB layout that involves various digital/analog power and ground traces. Designers should note that these are only 'rule-of-thumb' recommendations and the actual results will depend heavily on the final layout.

**General Mixed Signal Layout Recommendation**

**Power and Ground Circuits**

For two layer mixed signal design, it is important to isolate the digital power and ground trace paths from the analog power and ground trace paths. Star trace routing techniques (bringing individual traces back to a central point rather than daisy chaining traces together in a serial manner) can have a major impact on low level signal performance. Star trace routing refers to using individual traces to feed power and ground to each circuit or even device. This technique will take require a greater amount of design time but will not increase the final price of the board. The only extra parts required will be some jumpers.

**Single-Point Power / Ground Connections**

The analog power traces should be connected to the digital traces through a single point (link). A 'Pi-filter' can be helpful in minimizing high frequency noise coupling between the analog and digital sections. It is further recommended to put digital and analog power traces over the corresponding digital and analog ground traces to minimize noise coupling.
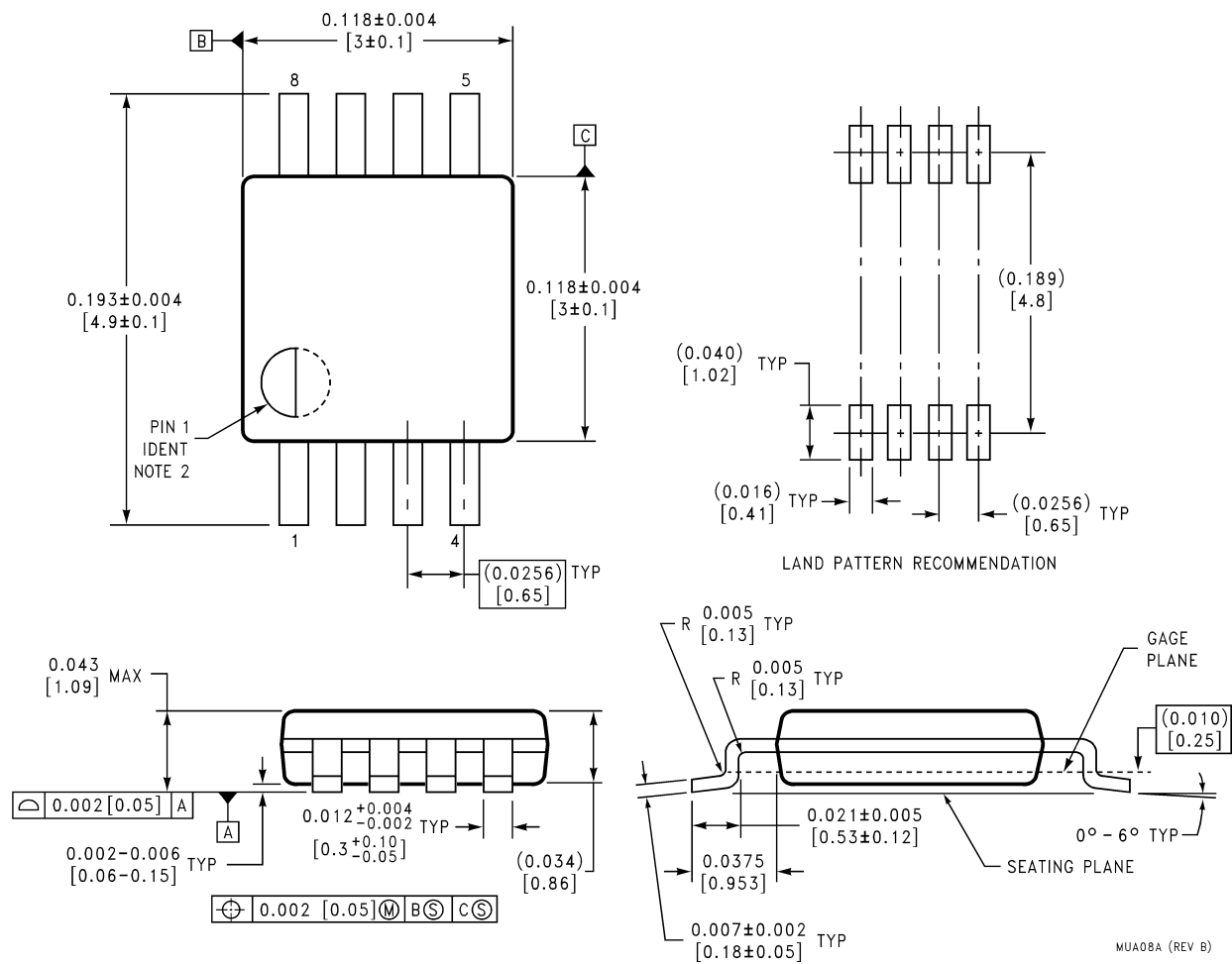
**Placement of Digital and Analog Components**

All digital components and high-speed digital signals traces should be located as far away as possible from analog components and circuit traces.
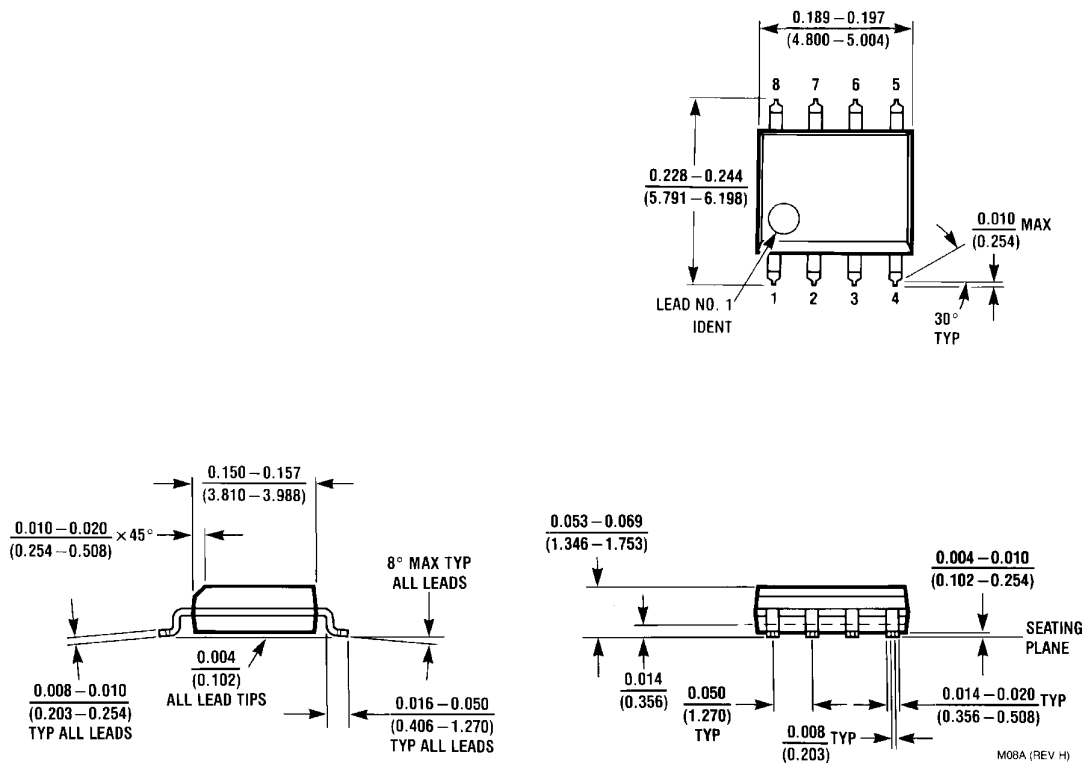
**Avoiding Typical Design / Layout Problems**

Avoid ground loops or running digital and analog traces parallel to each other (side-by-side) on the same PCB layer. When traces must cross over each other do it at 90 degrees. Running digital and analog traces at 90 degrees to each other from the top to the bottom side as much as possible will minimize capacitive noise coupling and cross talk.

# Physical Dimensions inches (millimeters) unless otherwise noted

0.118±0.004
[3±0.1]

B

8        5

C

0.193±0.004
[4.9±0.1]

0.118±0.004
[3±0.1]

PIN 1
IDENT
NOTE 2

1        4

(0.0256) TYP
[0.65]

(0.189)
[4.8]

(0.040) TYP
[1.02]

(0.016) TYP
[0.41]

(0.0256) TYP
[0.65]

LAND PATTERN RECOMMENDATION

0.043 MAX
[1.09]

⌂ 0.002[0.05] A

A

0.002-0.006 TYP
[0.06-0.15]

0.012 +0.004 −0.002 TYP
[0.3 +0.10 −0.05]

(0.034)
[0.86]

⊕ 0.002 [0.05] Ⓜ B Ⓢ C Ⓢ

R 0.005 TYP
[0.13]

R 0.005 TYP
[0.13]

GAGE
PLANE

(0.010)
[0.25]

0.021±0.005
[0.53±0.12]

0.0375
[0.953]

0.007±0.002 TYP
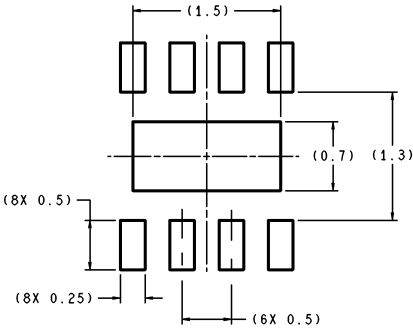[0.18±0.05]

0° – 6° TYP

SEATING PLANE

MUA08A (REV B)

**MSOP**
**Order Number HWD2119MM**

18

# Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

0.189 − 0.197
(4.800 − 5.004)

0.228 − 0.244
(5.791 − 6.198)

0.010 MAX
(0.254)

LEAD NO. 1
IDENT

30°
TYP

0.150 − 0.157
(3.810 − 3.988)

0.010 − 0.020 × 45°
(0.254 − 0.508)

8° MAX TYP
ALL LEADS

0.004
(0.102)
ALL LEAD TIPS

0.008 − 0.010
(0.203 − 0.254)
TYP ALL LEADS

0.016 − 0.050
(0.406 − 1.270)
TYP ALL LEADS

0.053 − 0.069
(1.346 − 1.753)

0.004 − 0.010
(0.102 − 0.254)

SEATING
PLANE

0.014
(0.356)

0.050
(1.270)
TYP

0.008 TYP
(0.203)

0.014 − 0.020 TYP
(0.356 − 0.508)

M08A (REV H)

**SO**
**Order Number HWD2119M**

(1.5)

(8X 0.5)

(0.7) (1.3)

(8X 0.25)

(6X 0.5)

RECOMMENDED LAND PATTERN
1:1 RATIO WITH PKG SOLDER PADS

DIMENSIONS ARE IN MILLIMETERS

PIN 1 INDEX AREA

2.5±0.1

B

2.5±0.1

A

C

0.8 MAX

(0.2)

PIN 1 ID

1.5±0.1

(0.1)

1    4

0.7±0.1

8X 0.5±0.1

8    5

8X 0.25±0.05

⊕ 0.1 Ⓜ C AⓈ BⓈ

6X 0.5

2X 1.5
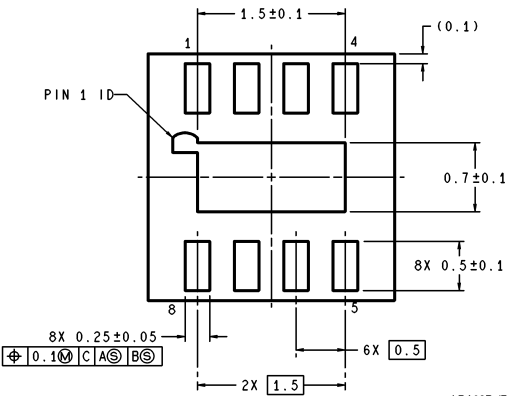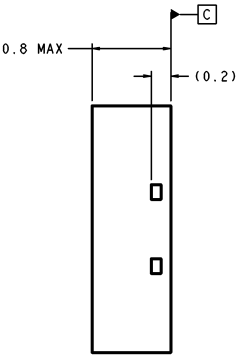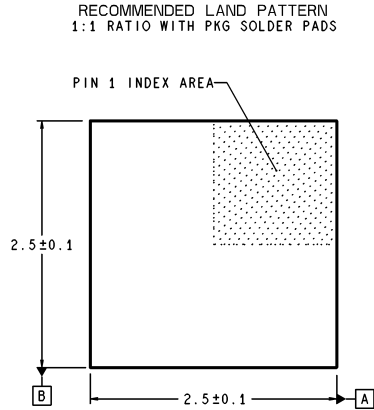
LDA08B (Rev A)

**LLP**
**Order Number HWD2119LD**

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# Chengdu Sino Microelectronics System Co.,Ltd

## (Http://www.csmsc.com)



## Headquarters of CSMSC:

Address: 2nd floor, Building D, Science & Technology Industrial Park, 11 Gaopeng Avenue, Chengdu High-Tech Zone,Chengdu City, Sichuan Province, P.R.China
PC: 610041
Tel: +86-28-8517-7737
Fax: +86-28-8517-5097

## Beijing Office:

Address: Room 505, No. 6 Building, Zijin Garden, 68 Wanquanhe Rd., Haidian District, Beijing, P.R.China
PC: 100000
Tel: +86-10-8265-8662
Fax: +86-10-8265-86

## Shenzhen Office:

Address: Room 1015, Building B, Zhongshen Garden, Caitian Rd, Futian District, Shenzhen, P.R.China
PC: 518000
Tel : +86-775-8299-5149
      +86-775-8299-5147
      +86-775-8299-6144
Fax:  +86-775-8299-6142