# LM4673 Boomer® Audio Power Amplifier Series Filterless, 2.65W, Mono, Class D Audio Power Amplifier

**Check for Samples: LM4673, LM4673SDBD, LM4673TMBD**

## FEATURES

- **Mono Class D Operation**
- **No Output Filter Required for Inductive Loads**
- **Externally Configurable Gain**
- **Very Fast Turn On Time: 17µs (typ)**
- **Minimum External Components**
- **"Click and Pop" Suppression Circuitry**
- **Micro-Power Shutdown Mode**
- **Available in Space-Saving 0.4mm Pitch DSBGA and WSON^Tm Packages**

## APPLICATIONS

- **Mobile Phones**
- **PDAs**
- **Portable Electronic Devices**

## KEY SPECIFICATIONS

- **Efficiency at 3.6V, 400mW into 8Ω Speaker 88% (typ)**
- **Efficiency at 3.6V, 100mW into 8Ω Speaker 80% (typ)**
- **Efficiency at 5V, 1W into 8Ω Speaker 86% (typ)**
- **Quiescent Current, 3.6V Supply 2.1mA (typ)**
- **Total Shutdown Power Supply Current 0.01µA (typ)**
- **Single Supply Range 2.4V to 5.5V**
- **PSRR, f = 217Hz 78dB**

## DESCRIPTION

The LM4673 is a single supply, high efficiency, 2.65W, mono, Class D audio amplifier. A low noise, filterless PWM architecture eliminates the output filter, reducing external component count, board area consumption, system cost, and simplifying design.

The LM4673 is designed to meet the demands of mobile phones and other portable communication devices. Operating on a single 5V supply, it is capable of driving a 4Ω speaker load at a continuous average output of 2.1W with less than 1% THD+N. Its flexible power supply requirements allow operation from 2.4V to 5.5V.

The LM4673 has high efficiency with speaker loads compared to a typical Class AB amplifier. With a 3.6V supply driving an 8Ω speaker, the IC's efficiency for a 100mW power level is 80%, reaching 88% at 400mW output power.

The LM4673 features a low-power consumption shutdown mode. Shutdown may be enabled by driving the Shutdown pin to a logic low (GND).

The gain of the LM4673 is externally configurable which allows independent gain control from multiple sources by summing the signals. Output short circuit and thermal overload protection prevent the device from damage during fault conditions.

## Typical Application

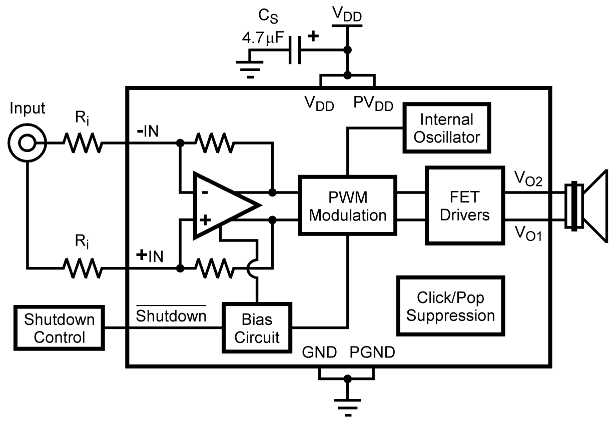



**Figure 1. Typical Audio Amplifier Application Circuit**

## Connection Diagram

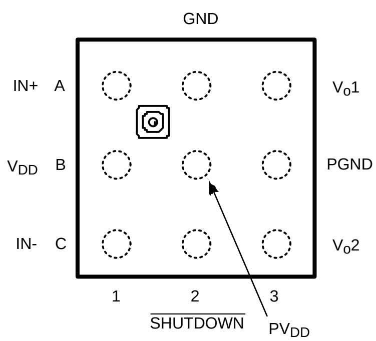



**Figure 2. 9-Bump DSBGA - Top View**
**See YFQ0009 Package**

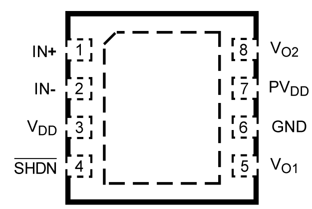



**Figure 3. 8-Pin WSON - Top View**
**See NGQ0008A**

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) | | 6.0V |
| Storage Temperature | | −65°C to +150°C |
| Voltage at Any Input Pin | | $V_{DD}$ + 0.3V ≥ V ≥ GND - 0.3V |
| Power Dissipation (4) | | Internally Limited |
| ESD Susceptibility, all other pins (5) | | 2.0kV |
| ESD Susceptibility (6) | | 200V |
| Junction Temperature ($T_{JMAX}$) | | 150°C |
| Thermal Resistance | $\theta_{JA}$ (DSBGA) | 99.1°C/W |
| | $\theta_{JA}$ (WSON) | 73°C/W |
| Soldering Information | | See (SNVA009) "microSMD Wafers Level Chip Scale Package." |

(1) All voltages are measured with respect to the ground pin, unless otherwise specified.
(2) *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 performance.
(3) If Military/Aerospace specified devices are required, please contact the TI 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 number given in Absolute Maximum Ratings, whichever is lower. For the LM4673, $T_{JMAX}$ = 150°C. The typical $\theta_{JA}$ is 99.1°C/W for the DSBGA package.
(5) Human body model, 100pF discharged through a 1.5kΩ resistor.
(6) Machine Model, 220pF – 240pF discharged through all pins.

## Operating Ratings (1) (2)

| | |
|---|---|
| Temperature Range $T_{MIN} \le T_A \le T_{MAX}$ | −40°C ≤ $T_A$ ≤ 85°C |
| Supply Voltage | 2.4V ≤ $V_{DD}$ ≤ 5.5V |

(1) All voltages are measured with respect to the ground pin, unless otherwise specified.
(2) *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 performance.

## Electrical Characteristics[1][2]

The following specifications apply for $A_V$ = 2V/V ($R_I$ = 150kΩ), $R_L$ = 15µH + 8Ω + 15µH unless otherwise specified. Limits apply for $T_A$ = 25°C.

| Symbol | Parameter | Conditions | LM4673 Typical[3] | LM4673 Limit[4][5] | Units (Limits) |
|---|---|---|---|---|---|
| $\|V_{OS}\|$ | Differential Output Offset Voltage | $V_I$ = 0V, $A_V$ = 2V/V,<br>$V_{DD}$ = 2.4V to 5.0V | 5 | | mV (max) |
| $\|I_{IH}\|$ | Logic High Input Current | $V_{DD}$ = 5.0V, $V_I$ = 5.5V | 17 | 100 | µA (max) |
| $\|I_{IL}\|$ | Logic Low Input Current | $V_{DD}$ = 5.0V, $V_I$ = –0.3V | 0.9 | 5 | µA (max) |
| $I_{DD}$ | Quiescent Power Supply Current | $V_{IN}$ = 0V, No Load, $V_{DD}$ = 5.0V | 2.6 | 3.75 | mA (max) |
| | | $V_{IN}$ = 0V, No Load, $V_{DD}$ = 3.6V | 2.1 | 2.9 | mA |
| | | $V_{IN}$ = 0V, No Load, $V_{DD}$ = 2.4V | 1.7 | 2.3 | mA (max) |
| | | $V_{IN}$ = 0V, $R_L$ = 8Ω, $V_{DD}$ = 5.0V | 2.6 | | |
| | | $V_{IN}$ = 0V, $R_L$ = 8Ω, $V_{DD}$ = 3.6V | 2.1 | | |
| | | $V_{IN}$ = 0V, $R_L$ = 8Ω, $V_{DD}$ = 2.4V | 1.7 | | |
| $I_{SD}$ | Shutdown Current[6] | $V_{SHUTDOWN}$ = 0V<br>$V_{DD}$ = 2.4V to 5.0V | 0.01 | 1 | µA (max) |
| $V_{SDIH}$ | Shutdown voltage input high | | | 1.4 | V (min) |
| $V_{SDIL}$ | Shutdown voltage input low | | | 0.4 | V (max) |
| $R_{OSD}$ | Output Impedance | $V_{SHUTDOWN}$ = 0.4V | 100 | | kΩ |
| $A_V$ | Gain | | 300kΩ/$R_I$ | 270kΩ/$R_I$<br>330kΩ/$R_I$ | V/V (min)<br>V/V (max) |
| $R_{SD}$ | Resistance from Shutdown Pin to GND | | 300 | | kΩ |
| $P_O$ | Output Power | $R_L$ = 15µH + 4Ω + 15µH<br>THD = 10% (max)<br>f = 1kHz, 22kHz BW<br>$V_{DD}$ = 5V<br>$V_{DD}$ = 3.6V<br>$V_{DD}$ = 2.5V | 2.65<br>1.3<br>550 | | W<br>W<br>mW |
| | | $R_L$ = 15µH + 4Ω + 15µH<br>THD = 1% (max)<br>f = 1kHz, 22kHz BW<br>$V_{DD}$ = 5V<br>$V_{DD}$ = 3.6V<br>$V_{DD}$ = 2.5V | 2.15<br>1.06<br>450 | | W<br>W<br>mW |

(1) All voltages are measured with respect to the ground pin, unless otherwise specified.
(2) *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 performance.
(3) Typical specifications are specified at 25°C and represent the parametric norm.
(4) Tested limits are guaranteed to TI's AOQL (Average Outgoing Quality Level).
(5) Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.
(6) Shutdown current is measured in a normal room environment. Exposure to direct sunlight will increase $I_{SD}$ by a maximum of 2µA. The Shutdown pin should be driven as close as possible to GND for minimal shutdown current and to $V_{DD}$ for the best THD performance in PLAY mode. See the Application Information section under SHUTDOWN FUNCTION for more information.

## Electrical Characteristics(1)(2) (continued)

The following specifications apply for $A_V$ = 2V/V ($R_I$ = 150kΩ), $R_L$ = 15µH + 8Ω + 15µH unless otherwise specified. Limits apply for $T_A$ = 25°C.

| Symbol | Parameter | Conditions | LM4673 Typical(3) | LM4673 Limit(4)(5) | Units (Limits) |
|---|---|---|---|---|---|
| $P_O$ | Output Power | $R_L$ = 15µH + 8Ω + 15µH<br>THD = 10% (max)<br>f = 1kHz, 22kHz BW | | | |
| | | $V_{DD}$ = 5V | 1.7 | | W |
| | | $V_{DD}$ = 3.6V | 870 | | mW |
| | | $V_{DD}$ = 2.5V | 350 | | mW |
| | | $R_L$ = 15µH + 8Ω + 15µH<br>THD = 1% (max)<br>f = 1kHz, 22kHz BW | | | |
| | | $V_{DD}$ = 5V | 1.24 | | W |
| | | $V_{DD}$ = 3.6V | 650 | 600 | mW |
| | | $V_{DD}$ = 2.5V | 300 | | mW |
| THD+N | Total Harmonic Distortion + Noise | $V_{DD}$ = 5V, $P_O$ = 0.1W, f = 1kHz | 0.03 | | % |
| | | $V_{DD}$ = 3.6V, $P_O$ = 0.1W, f = 1kHz | 0.02 | | % |
| | | $V_{DD}$ = 2.5V, $P_O$ = 0.1W, f = 1kHz | 0.02 | | % |
| PSRR | Power Supply Rejection Ratio (Input Referred) | $V_{Ripple}$ = 200m$V_{PP}$ Sine,<br>$f_{Ripple}$ = 217Hz, $V_{DD}$ = 3.6, 5V<br>Inputs to AC GND, $C_I$ = 2µF | 78 | | dB |
| | | $V_{Ripple}$ = 200m$V_{PP}$ Sine,<br>$f_{Ripple}$ = 1kHz, $V_{DD}$ = 3.6, 5V<br>Inputs to AC GND, $C_I$ = 2µF | 72 | | dB |
| SNR | Signal to Noise Ratio | $V_{DD}$ = 5V, $P_O$ = 1$W_{RMS}$ | 97 | | dB |
| $\varepsilon_{OUT}$ | Output Noise (Input Referred) | $V_{DD}$ = 3.6V, f = 20Hz – 20kHz<br>Inputs to AC GND, $C_I$ = 2µF<br>No Weighting | 30 | | µ$V_{RMS}$ |
| | | $V_{DD}$ = 3.6V, Inputs to AC GND<br>$C_I$ = 2µF, A Weighted | 23 | | µ$V_{RMS}$ |
| CMRR | Common Mode Rejection Ratio (Input Referred) | $V_{DD}$ = 3.6V, $V_{Ripple}$ = 1$V_{PP}$ Sine<br>$f_{Ripple}$ = 217Hz | 70 | | dB |
| $T_{WU}$ | Wake-up Time | $V_{DD}$ = 3.6V | 17 | | µs |
| $T_{SD}$ | Shutdown Time | | 140 | | µs |
| η | Efficiency | $V_{DD}$ = 3.6V, $P_{OUT}$ = 400mW<br>$R_L$ = 8Ω | 88 | | % |
| | | $V_{DD}$ = 5V, $P_{OUT}$ = 1W<br>$R_L$ = 8Ω | 86 | | % |

## External Components Description

(Figure 1)

| Components | | Functional Description |
|---|---|---|
| 1. | $C_S$ | 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. |
| 2. | $C_I$ | Input AC coupling capacitor which blocks the DC voltage at the amplifier's input terminals. |

## Typical Performance Characteristics

The performance graphs were taken using the Audio Precision AUX-0025 Switching Amplifier measurement Filter in series with the LC filter on the demo board.

**THD + N vs Output Power**
**f = 1kHz, $R_L$ = 8Ω**

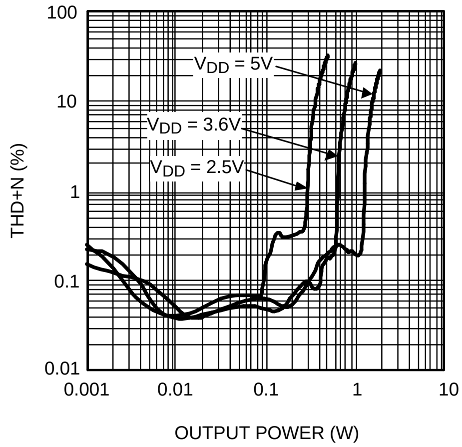



**Figure 4.**

**THD + N vs Output Power**
**f = 1kHz, $R_L$ = 4Ω**

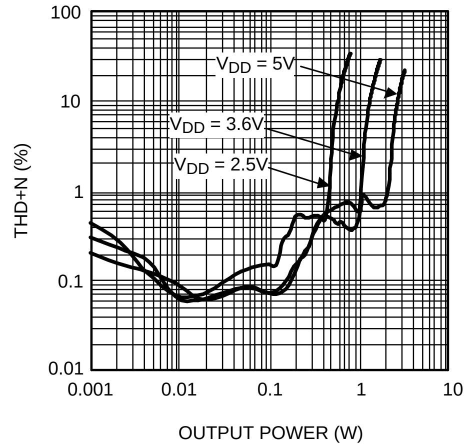



**Figure 5.**

**THD + N vs Frequency**
**$V_{DD}$ = 2.5V, $P_{OUT}$ = 100mW, $R_L$ = 8Ω**

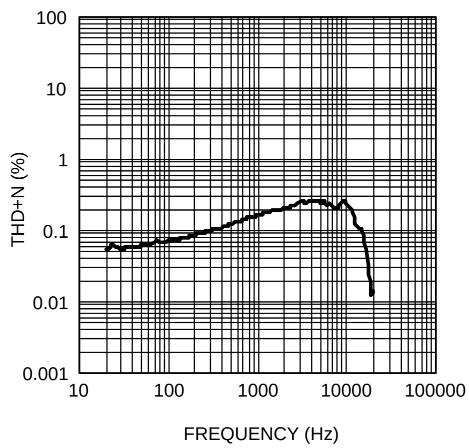



**Figure 6.**

**THD + N vs Frequency**
**$V_{DD}$ = 3.6V, $P_{OUT}$ = 150mW, $R_L$ = 8Ω**

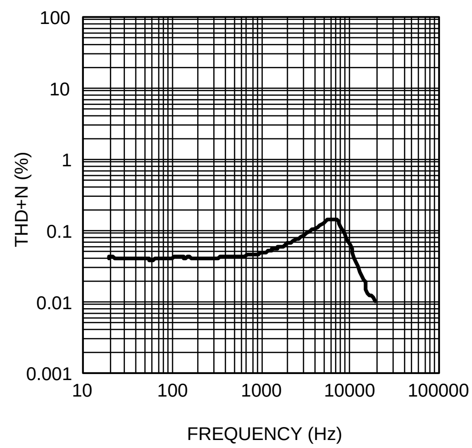



**Figure 7.**

## Typical Performance Characteristics (continued)

The performance graphs were taken using the Audio Precision AUX-0025 Switching Amplifier measurement Filter in series with the LC filter on the demo board.

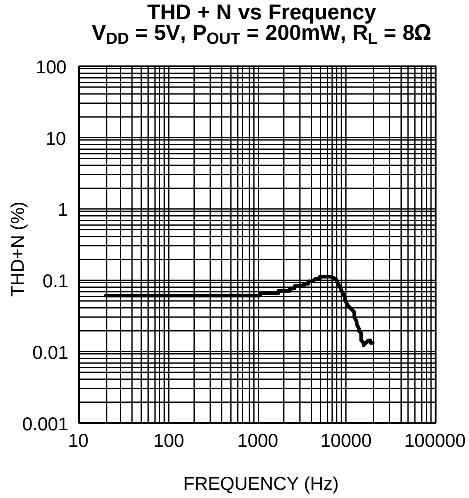



**Figure 8.**

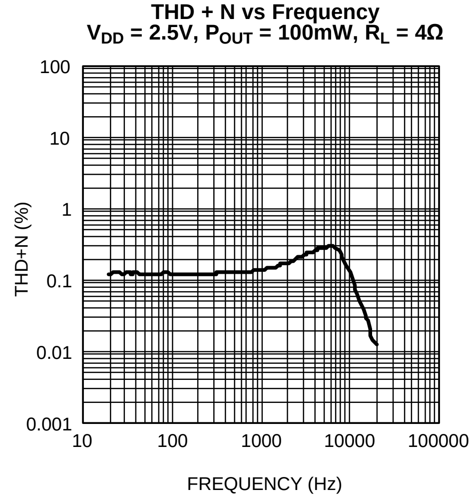



**Figure 9.**

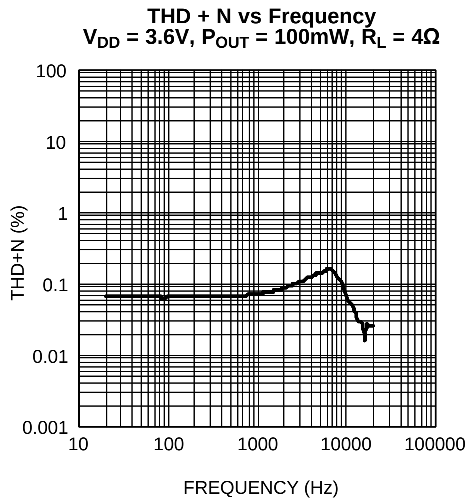



**Figure 10.**

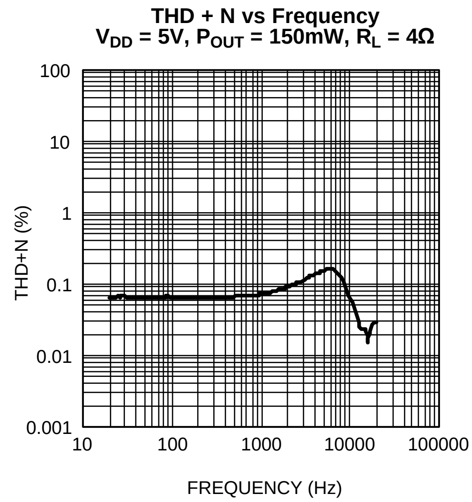



**Figure 11.**

## Typical Performance Characteristics (continued)

The performance graphs were taken using the Audio Precision AUX-0025 Switching Amplifier measurement Filter in series with the LC filter on the demo board.

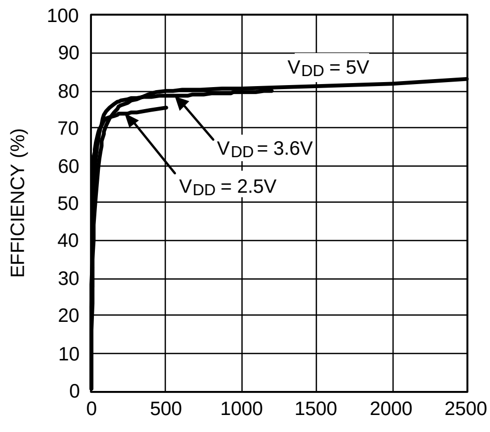



**Figure 12.**

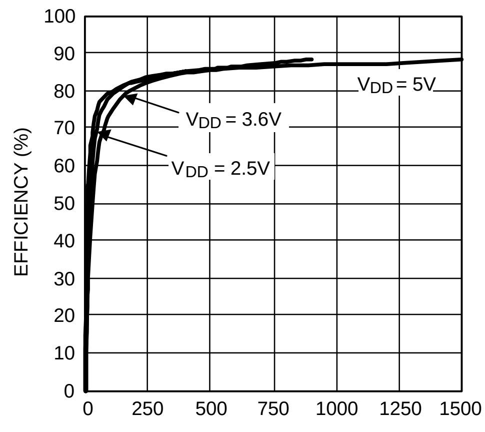



**Figure 13.**

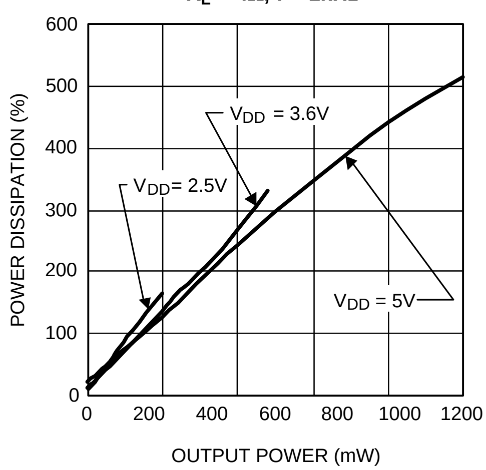



**Figure 14.**

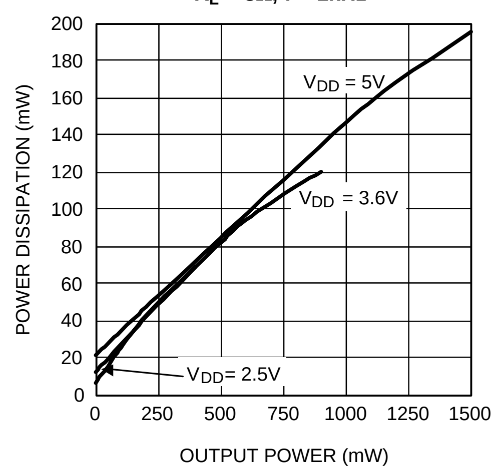



**Figure 15.**

## Typical Performance Characteristics (continued)

The performance graphs were taken using the Audio Precision AUX-0025 Switching Amplifier measurement Filter in series with the LC filter on the demo board.

**Output Power vs. Supply Voltage**
**$R_L$ = 4Ω, f = 1kHz**

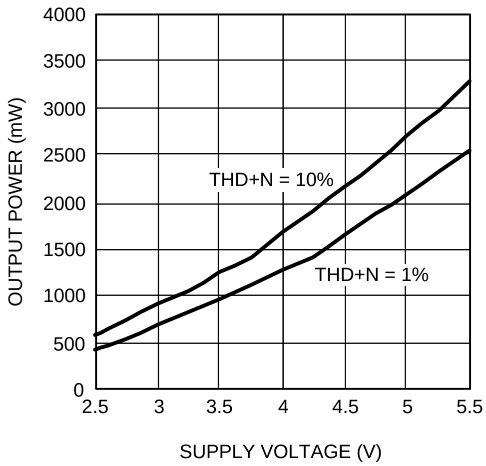



**Figure 16.**

**Output Power vs. Supply Voltage**
**$R_L$ = 8Ω, f = 1kHz**

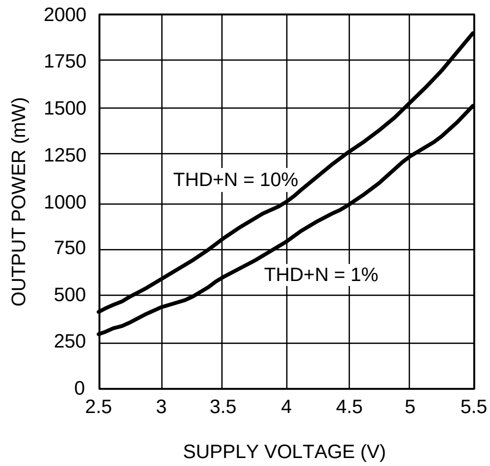



**Figure 17.**

**PSRR vs. Frequency**
**$V_{DD}$ = 3.6V ,$V_{RIPPLE}$ = 200m$V_{P-P}$, $R_L$ = 8Ω**

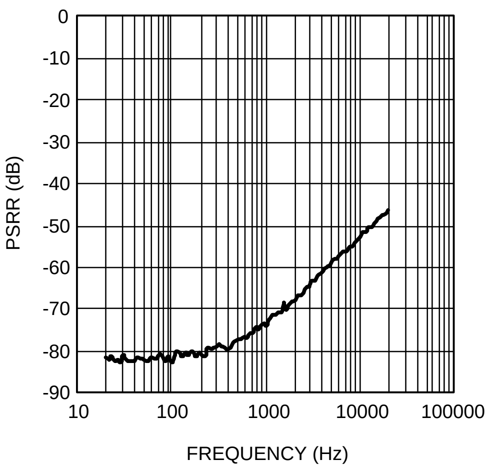



**Figure 18.**

**CMRR vs. Frequency**
**$V_{DD}$ = 3.6V, $V_{CM}$ = 1$V_{P-P}$, $R_L$ = 8Ω**

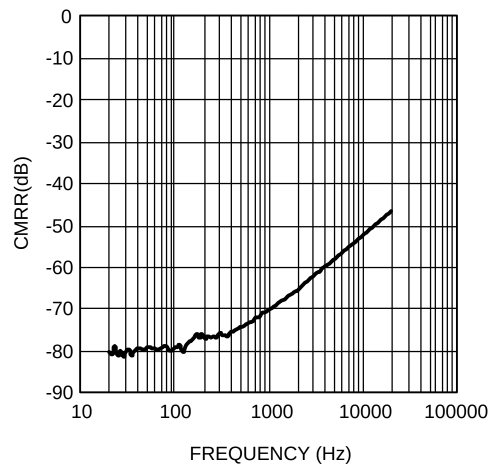



**Figure 19.**

## Typical Performance Characteristics (continued)

The performance graphs were taken using the Audio Precision AUX-0025 Switching Amplifier measurement Filter in series with the LC filter on the demo board.

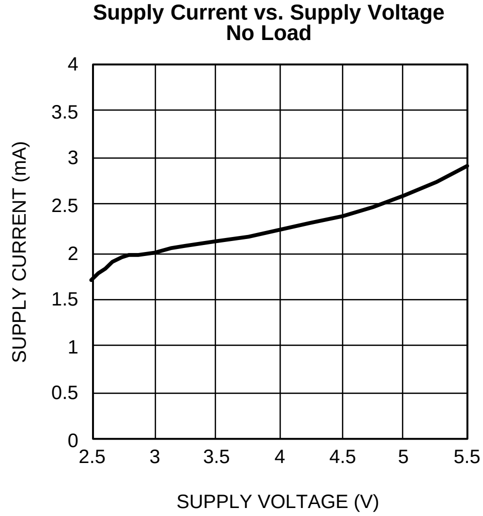



**Figure 20.**

# APPLICATION INFORMATION

## GENERAL AMPLIFIER FUNCTION

The LM4673 features a filterless modulation scheme. The differential outputs of the device switch at 300kHz from $V_{DD}$ to GND. When there is no input signal applied, the two outputs ($V_O1$ and $V_O2$) switch with a 50% duty cycle, with both outputs in phase. Because the outputs of the LM4673 are differential, the two signals cancel each other. This results in no net voltage across the speaker, thus there is no load current during an idle state, conserving power.

With an input signal applied, the duty cycle (pulse width) of the LM4673 outputs changes. For increasing output voltages, the duty cycle of $V_O1$ increases, while the duty cycle of $V_O2$ decreases. For decreasing output voltages, the converse occurs, the duty cycle of $V_O2$ increases while the duty cycle of $V_O1$ decreases. The difference between the two pulse widths yields the differential output voltage.

## POWER DISSIPATION AND EFFICIENCY

In general terms, efficiency is considered to be the ratio of useful work output divided by the total energy required to produce it with the difference being the power dissipated, typically, in the IC. The key here is “useful” work. For audio systems, the energy delivered in the audible bands is considered useful including the distortion products of the input signal. Sub-sonic (DC) and super-sonic components (>22kHz) are not useful. The difference between the power flowing from the power supply and the audio band power being transduced is dissipated in the LM4673 and in the transducer load. The amount of power dissipation in the LM4673 is very low. This is because the ON resistance of the switches used to form the output waveforms is typically less than 0.25Ω. This leaves only the transducer load as a potential "sink" for the small excess of input power over audio band output power. The LM4673 dissipates only a fraction of the excess power requiring no additional PCB area or copper plane to act as a heat sink.

## DIFFERENTIAL AMPLIFIER EXPLANATION

As logic supply voltages continue to shrink, designers are increasingly turning to differential analog signal handling to preserve signal to noise ratios with restricted voltage swing. The LM4673 is a fully differential amplifier that features differential input and output stages. A differential amplifier amplifies the difference between the two input signals. Traditional audio power amplifiers have typically offered only single-ended inputs resulting in a 6dB reduction in signal to noise ratio relative to differential inputs. The LM4673 also offers the possibility of DC input coupling which eliminates the two external AC coupling, DC blocking capacitors. The LM4673 can be used, however, as a single ended input amplifier while still retaining it's fully differential benefits. In fact, completely unrelated signals may be placed on the input pins. The LM4673 simply amplifies the difference between the signals. A major benefit of a differential amplifier is the improved common mode rejection ratio (CMRR) over single input amplifiers. The common-mode rejection characteristic of the differential amplifier reduces sensitivity to ground offset related noise injection, especially important in high noise applications.

## PCB LAYOUT CONSIDERATIONS

As output power increases, interconnect resistance (PCB traces and wires) between the amplifier, load and power supply create a voltage drop. The voltage loss on the traces between the LM4673 and the load results is lower output power and decreased efficiency. Higher trace resistance between the supply and the LM4673 has the same effect as a poorly regulated supply, increased ripple on the supply line also reducing the peak output power. The effects of residual trace resistance increases as output current increases due to higher output power, decreased load impedance or both. To maintain the highest output voltage swing and corresponding peak output power, the PCB traces that connect the output pins to the load and the supply pins to the power supply should be as wide as possible to minimize trace resistance.

The use of power and ground planes will give the best THD+N performance. While reducing trace resistance, the use of power planes also creates parasite capacitors that help to filter the power supply line.

The inductive nature of the transducer load can also result in overshoot on one or both edges, clamped by the parasitic diodes to GND and $V_{DD}$ in each case. From an EMI standpoint, this is an aggressive waveform that can radiate or conduct to other components in the system and cause interference. It is essential to keep the power and output traces short and well shielded if possible. Use of ground planes, beads, and micro-strip layout techniques are all useful in preventing unwanted interference.

As the distance from the LM4673 and the speaker increase, the amount of EMI radiation will increase since the output wires or traces acting as antenna become more efficient with length. What is acceptable EMI is highly application specific. Ferrite chip inductors placed close to the LM4673 may be needed to reduce EMI radiation. The value of the ferrite chip is very application specific.

## POWER SUPPLY BYPASSING

As with any power amplifier, proper supply bypassing is critical for low noise performance and high power supply rejection ratio (PSRR). The capacitor ($C_S$) location should be as close as possible to the LM4673. Typical applications employ a voltage regulator with a 10µF and a 0.1µF bypass capacitors that increase supply stability. These capacitors do not eliminate the need for bypassing on the supply pin of the LM4673. A 4.7µF tantalum capacitor is recommended.

## SHUTDOWN FUNCTION

In order to reduce power consumption while not in use, the LM4673 contains shutdown circuitry that reduces current draw to less than 0.01µA. The trigger point for shutdown is shown as a typical value in the Electrical Characteristics Tables and in the Shutdown Hysteresis Voltage graphs found in the Typical Performance Characteristics section. It is best to switch between ground and supply for minimum current usage while in the shutdown state. While the LM4673 may be disabled with shutdown voltages in between ground and supply, the idle current will be greater than the typical 0.01µA value.

The LM4673 has an internal resistor connected between GND and Shutdown pins. The purpose of this resistor is to eliminate any unwanted state changes when the Shutdown pin is floating. The LM4673 will enter the shutdown state when the Shutdown pin is left floating or if not floating, when the shutdown voltage has crossed the threshold. To minimize the supply current while in the shutdown state, the Shutdown pin should be driven to GND or left floating. If the Shutdown pin is not driven to GND, the amount of additional resistor current due to the internal shutdown resistor can be found by Equation 1 below.

$$(V_{SD} - GND) / 300k\Omega \quad (1)$$

With only a 0.5V difference, an additional 1.7µA of current will be drawn while in the shutdown state.

## PROPER SELECTION OF EXTERNAL COMPONENTS

The gain of the LM4673 is set by the external resistors, Ri in Typical Application, The Gain is given by Equation 2 below. Best THD+N performance is achieved with a gain of 2V/V (6dB).

$$A_V = 2 * 150\ k\Omega / R_i\ (V/V) \quad (2)$$

It is recommended that resistors with 1% tolerance or better be used to set the gain of the LM4673. The Ri resistors should be placed close to the input pins of the LM4673. Keeping the input traces close to each other and of the same length in a high noise environment will aid in noise rejection due to the good CMRR of the LM4673. Noise coupled onto input traces which are physically close to each other will be common mode and easily rejected by the LM4673.

Input capacitors may be needed for some applications or when the source is single-ended (see Figure 22, Figure 24). Input capacitors are needed to block any DC voltage at the source so that the DC voltage seen between the input terminals of the LM4673 is 0V. Input capacitors create a high-pass filter with the input resistors, $R_i$. The –3dB point of the high-pass filter is found using Equation 3 below.

$$f_C = 1 / (2\pi R_i C_i)\ (Hz) \quad (3)$$

The input capacitors may also be used to remove low audio frequencies. Small speakers cannot reproduce low bass frequencies so filtering may be desired . When the LM4673 is using a single-ended source, power supply noise on the ground is seen as an input signal by the +IN input pin that is capacitor coupled to ground (See Figure 24 – Figure 26). Setting the high-pass filter point above the power supply noise frequencies, 217Hz in a GSM phone, for example, will filter out this noise so it is not amplified and heard on the output. Capacitors with a tolerance of 10% or better are recommended for impedance matching.

## DIFFERENTIAL CIRCUIT CONFIGURATIONS

The LM4673 can be used in many different circuit configurations. The simplest and best performing is the DC coupled, differential input configuration shown in Figure 21. Equation 2 above is used to determine the value of the $R_i$ resistors for a desired gain.

Input capacitors can be used in a differential configuration as shown in Figure 22. Equation 3 above is used to determine the value of the $C_i$ capacitors for a desired frequency response due to the high-pass filter created by $C_i$ and $R_i$. Equation 2 above is used to determine the value of the $R_i$ resistors for a desired gain.

The LM4673 can be used to amplify more than one audio source. Figure 23 shows a dual differential input configuration. The gain for each input can be independently set for maximum design flexibility using the $R_i$ resistors for each input and Equation 2. Input capacitors can be used with one or more sources as well to have different frequency responses depending on the source or if a DC voltage needs to be blocked from a source.

## SINGLE-ENDED CIRCUIT CONFIGURATIONS

The LM4673 can also be used with single-ended sources but input capacitors will be needed to block any DC at the input terminals. Figure 24 shows the typical single-ended application configuration. The equations for Gain, Equation 2, and frequency response, Equation 3, hold for the single-ended configuration as shown in Figure 24.

When using more than one single-ended source as shown in Figure 25, the impedance seen from each input terminal should be equal. To find the correct values for $C_{i3}$ and $R_{i3}$ connected to the +IN input pin the equivalent impedance of all the single-ended sources are calculated. The single-ended sources are in parallel to each other. The equivalent capacitor and resistor, $C_{i3}$ and $R_{i3}$, are found by calculating the parallel combination of all $C_i$values and then all $R_i$ values. Equation 4 and Equation 5 below are for any number of single-ended sources.

$$C_{i3} = C_{i1} + C_{i2} + C_{in} \ldots \text{ (F)} \qquad (4)$$

$$R_{i3} = 1 / (1/R_{i1} + 1/R_{i2} + 1/R_{in} \ldots) \ (\Omega) \qquad (5)$$

The LM4673 may also use a combination of single-ended and differential sources. A typical application with one single-ended source and one differential source is shown in Figure 26. Using the principle of superposition, the external component values can be determined with the above equations corresponding to the configuration.

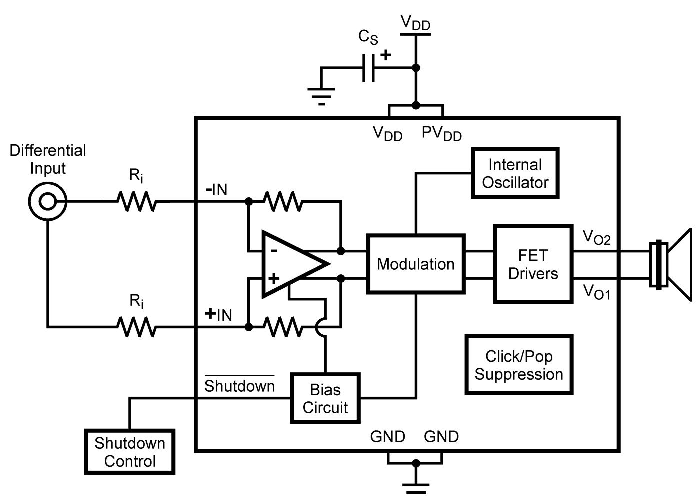



**Figure 21. Differential Input Configuration**

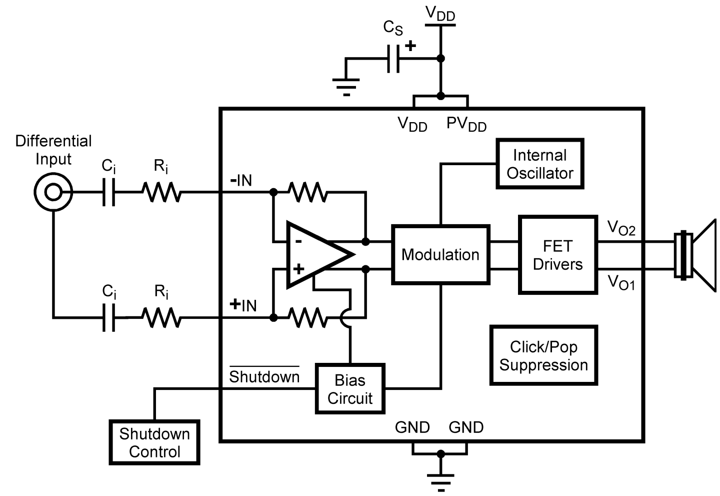



**Figure 22. Differential Input Configuration with Input Capacitors**

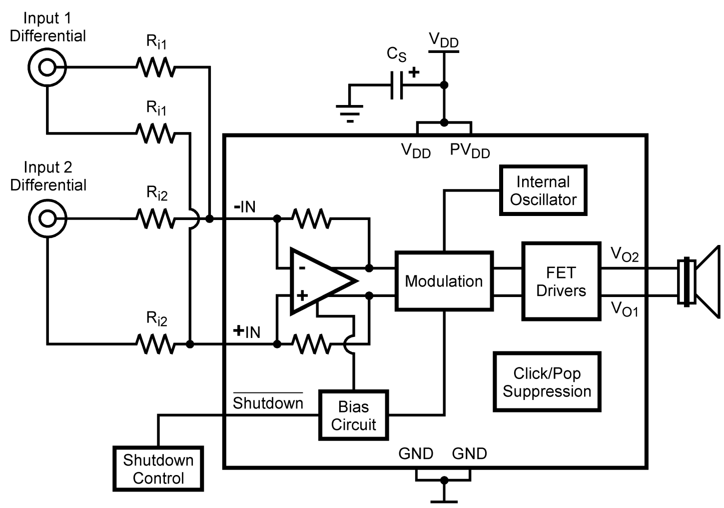



**Figure 23. Dual Differential Input Configuration**

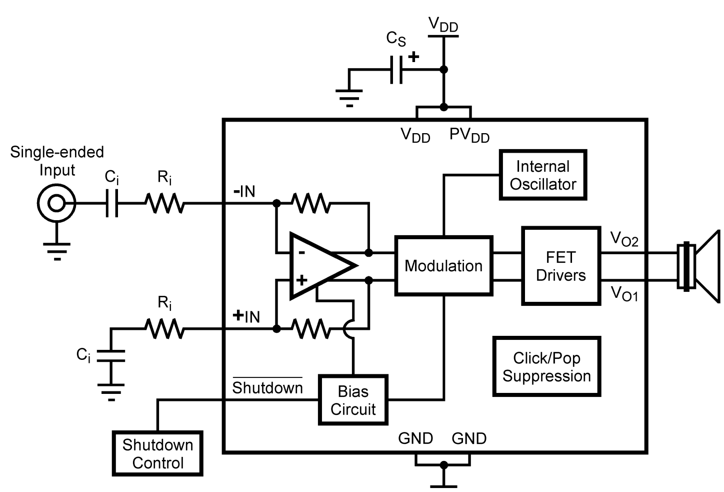



**Figure 24. Single-Ended Input Configuration**

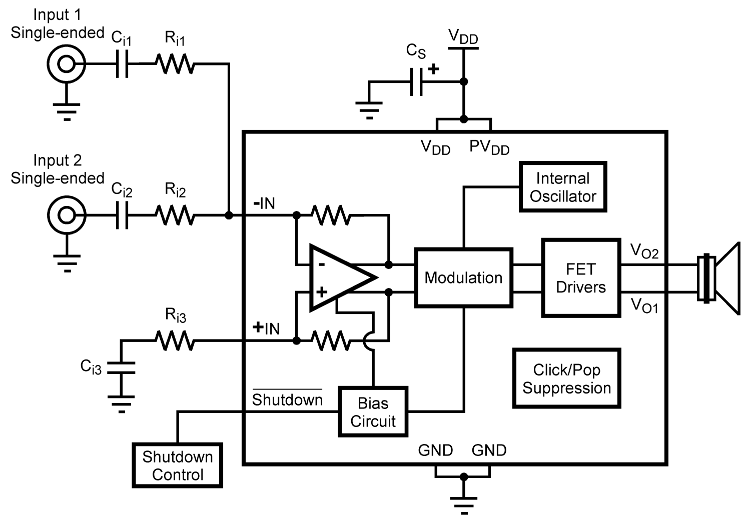



**Figure 25. Dual Single-Ended Input Configuration**

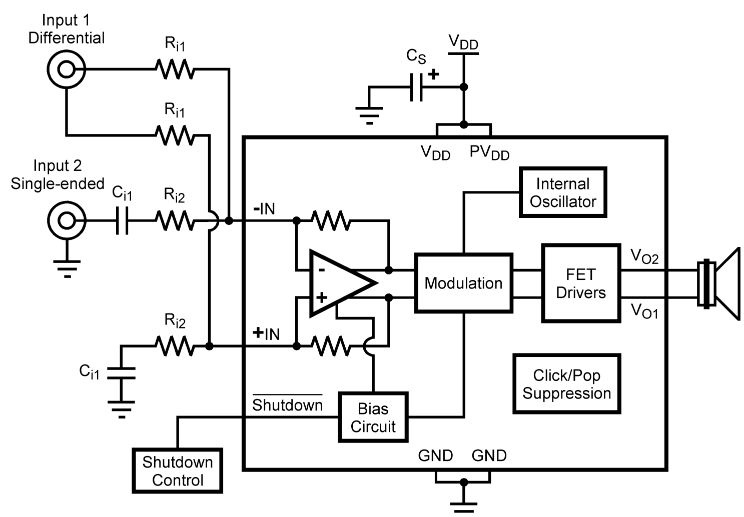
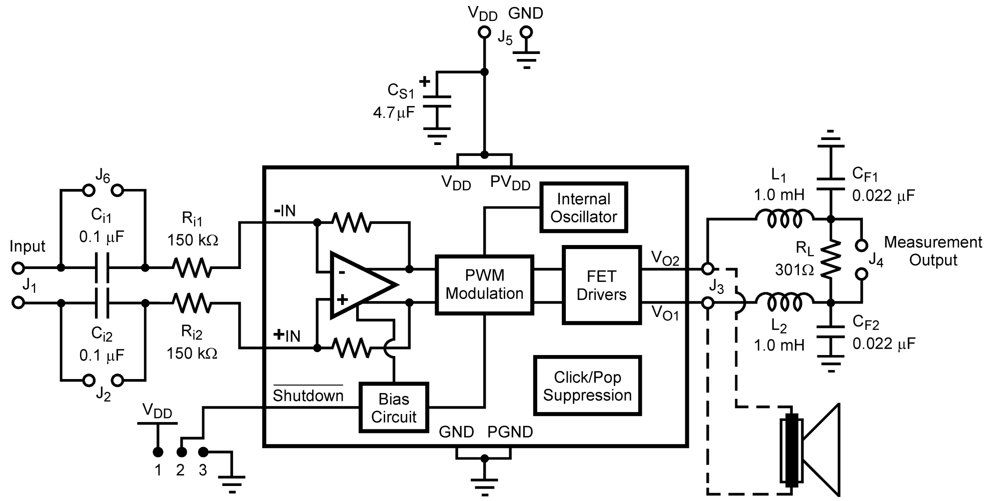



**Figure 26. Dual Input with a Single-Ended Input and a Differential Input**

## REFERENCE DESIGN BOARD SCHEMATIC




In addition to the minimal parts required for the application circuit, a measurement filter is provided on the evaluation circuit board so that conventional audio measurements can be conveniently made without additional equipment. This is a balanced input, grounded differential output low pass filter with a 3dB frequency of approximately 35kHz and an on board termination resistor of 300Ω (see schematic). Note that the capacitive load elements are returned to ground. This is not optimal for common mode rejection purposes, but due to the independent pulse format at each output there is a significant amount of high frequency common mode component on the outputs. The grounded capacitive filter elements attenuate this component at the board to reduce the high frequency CMRR requirement placed on the analysis instruments.

Even with the grounded filter the audio signal is still differential, necessitating a differential input on any analysis instrument connected to it. Most lab instruments that feature BNC connectors on their inputs are **NOT** differential responding because the ring of the BNC is usually grounded.

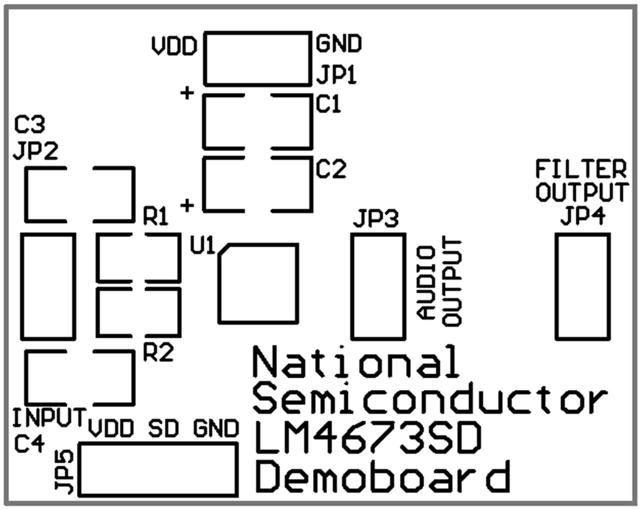
The commonly used Audio Precision analyzer is differential, but its ability to accurately reject high frequency signals is questionable necessitating the on board measurement filter. When in doubt or when the signal needs to be single-ended, use an audio signal transformer to convert the differential output to a single ended output. Depending on the audio transformer's characteristics, there may be some attenuation of the audio signal which needs to be taken into account for correct measurement of performance.

Measurements made at the output of the measurement filter suffer attenuation relative to the primary, unfiltered outputs even at audio frequencies. This is due to the resistance of the inductors interacting with the termination resistor (300Ω) and is typically about -0.25dB (3%). In other words, the voltage levels (and corresponding power levels) indicated through the measurement filter are slightly lower than those that actually occur at the load placed on the unfiltered outputs. This small loss in the filter for measurement gives a lower output power reading than what is really occurring on the unfiltered outputs and its load.

## LM4673SD Demo Board Artwork

**Top Silkscreen**

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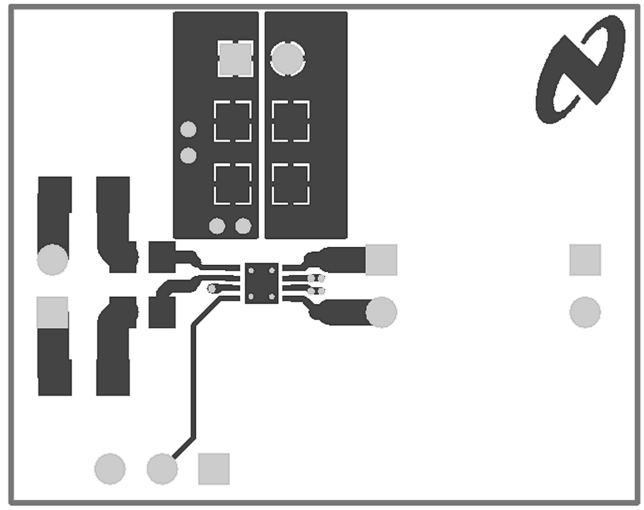
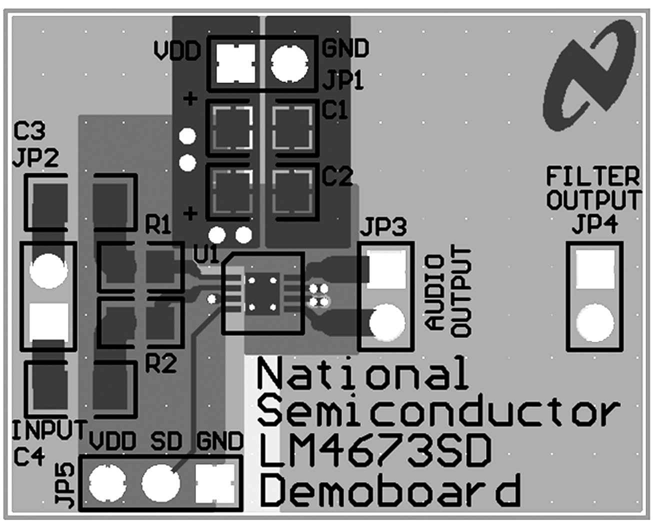
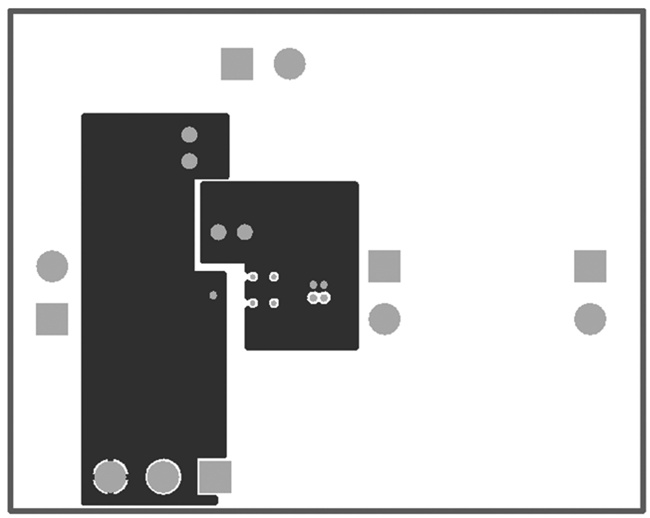


**Composite View**




**Internal Layer 1**



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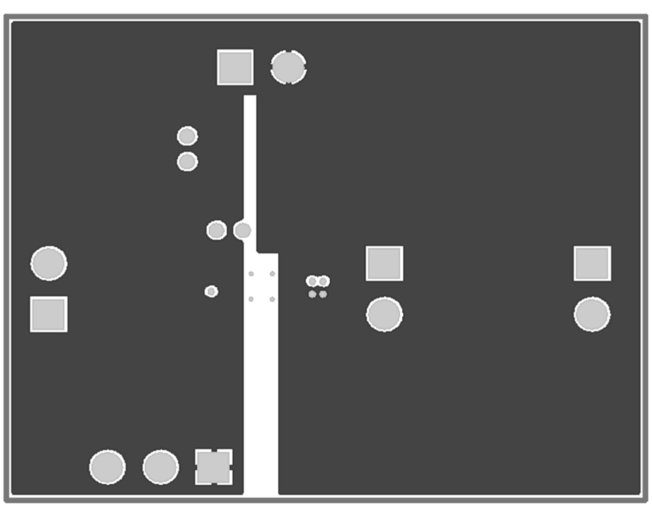
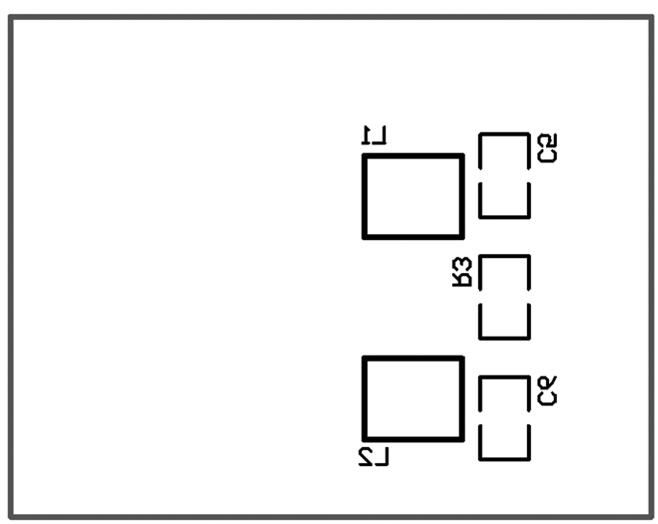


**Bottom Silkscreen**



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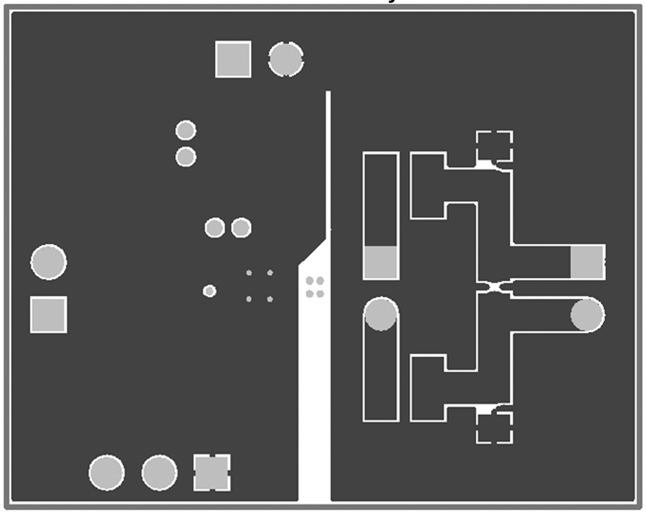

### LM4673TM Demo Board Artwork

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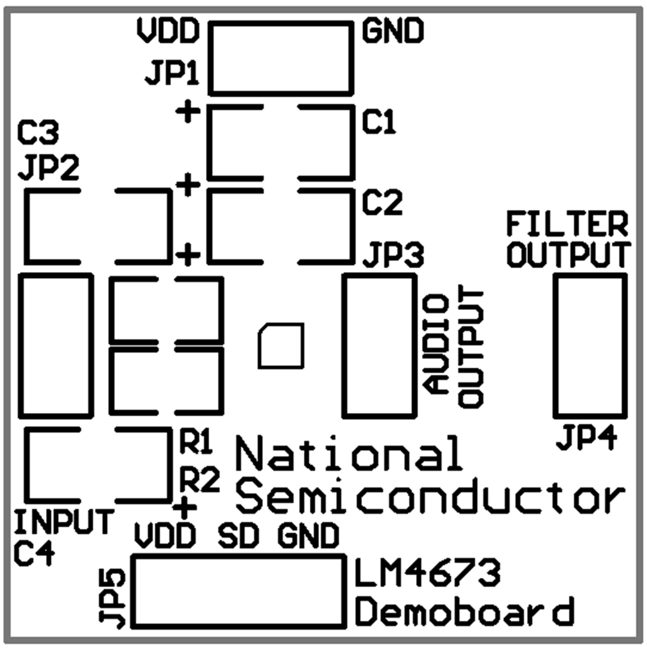


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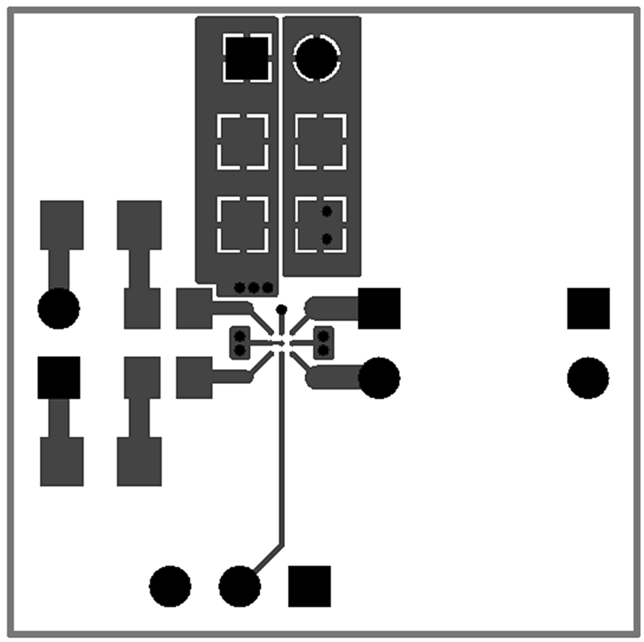
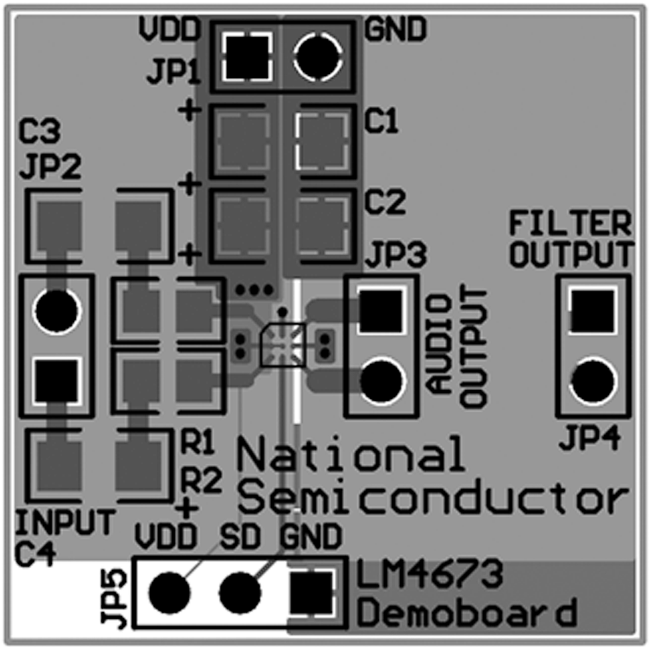


**Composite View**

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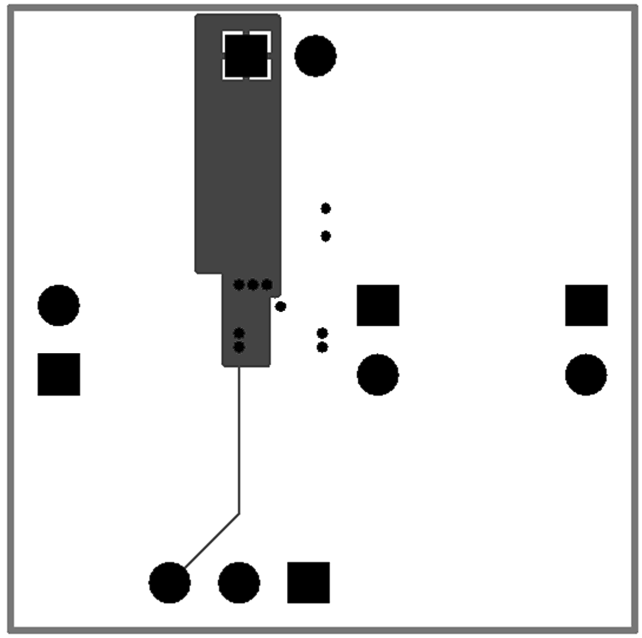

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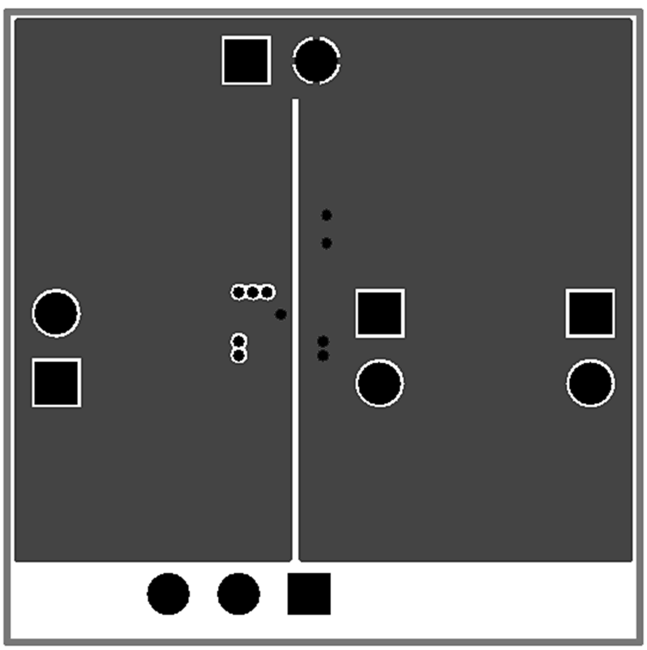

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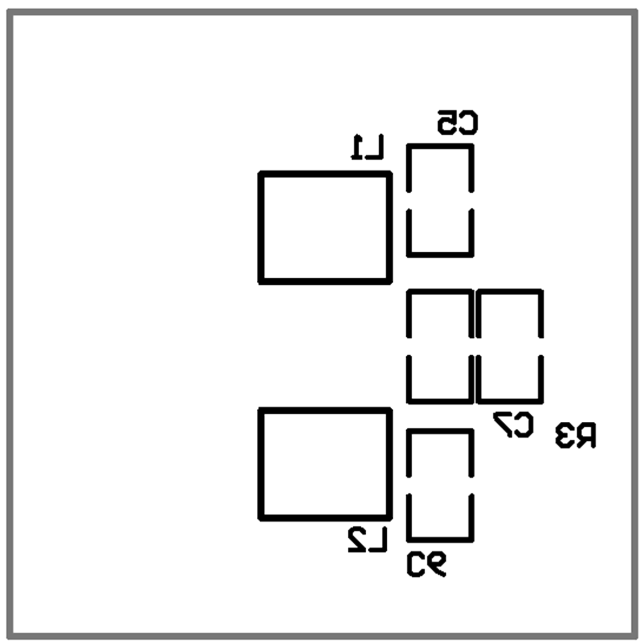

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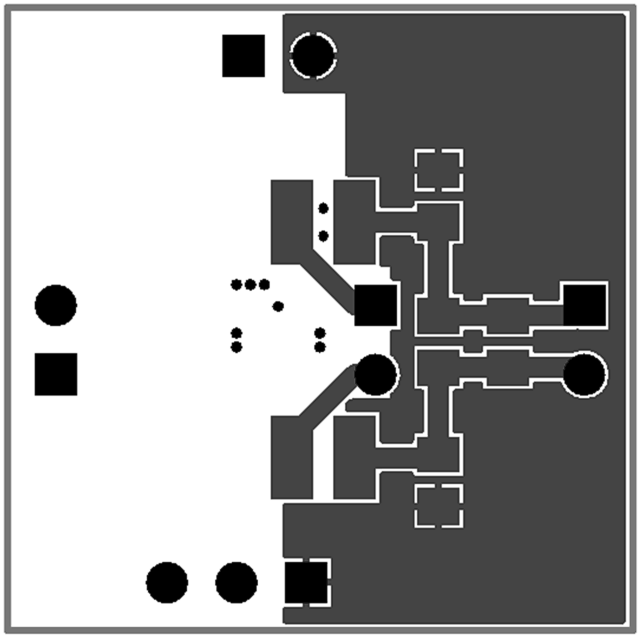

## REVISION HISTORY

| Rev | Date | Description |
|---|---|---|
| 1.0 | 12/16/05 | Initial WEB released. |
| 1.1 | 02/28/06 | Taken out “Future Product”, then re-WEBd the datasheet. |
| 1.2 | 04/06/06 | Added the TM and SD demo boards, then released to the WEB (per Royce). |
| 1.3 | 11/01/07 | Deleted a sentence under the SHUTDOWN FUNCTION section. |

## 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LM4673SD/NOPB | ACTIVE | WSON | NGQ | 8 | 1000 | Green (RoHS & no Sb/Br) | CU SN | Level-1-260C-UNLIM | -40 to 85 | L4673 | Samples |
| LM4673SDX/NOPB | ACTIVE | WSON | NGQ | 8 | 4500 | Green (RoHS & no Sb/Br) | CU SN | Level-1-260C-UNLIM | -40 to 85 | L4673 | Samples |
| LM4673TM/NOPB | ACTIVE | DSBGA | YFQ | 9 | 250 | Green (RoHS & no Sb/Br) | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | G G4 | Samples |
| LM4673TMX/NOPB | ACTIVE | DSBGA | YFQ | 9 | 3000 | Green (RoHS & no Sb/Br) | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | G G4 | 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) Only one of markings shown within the brackets will appear on the physical device.

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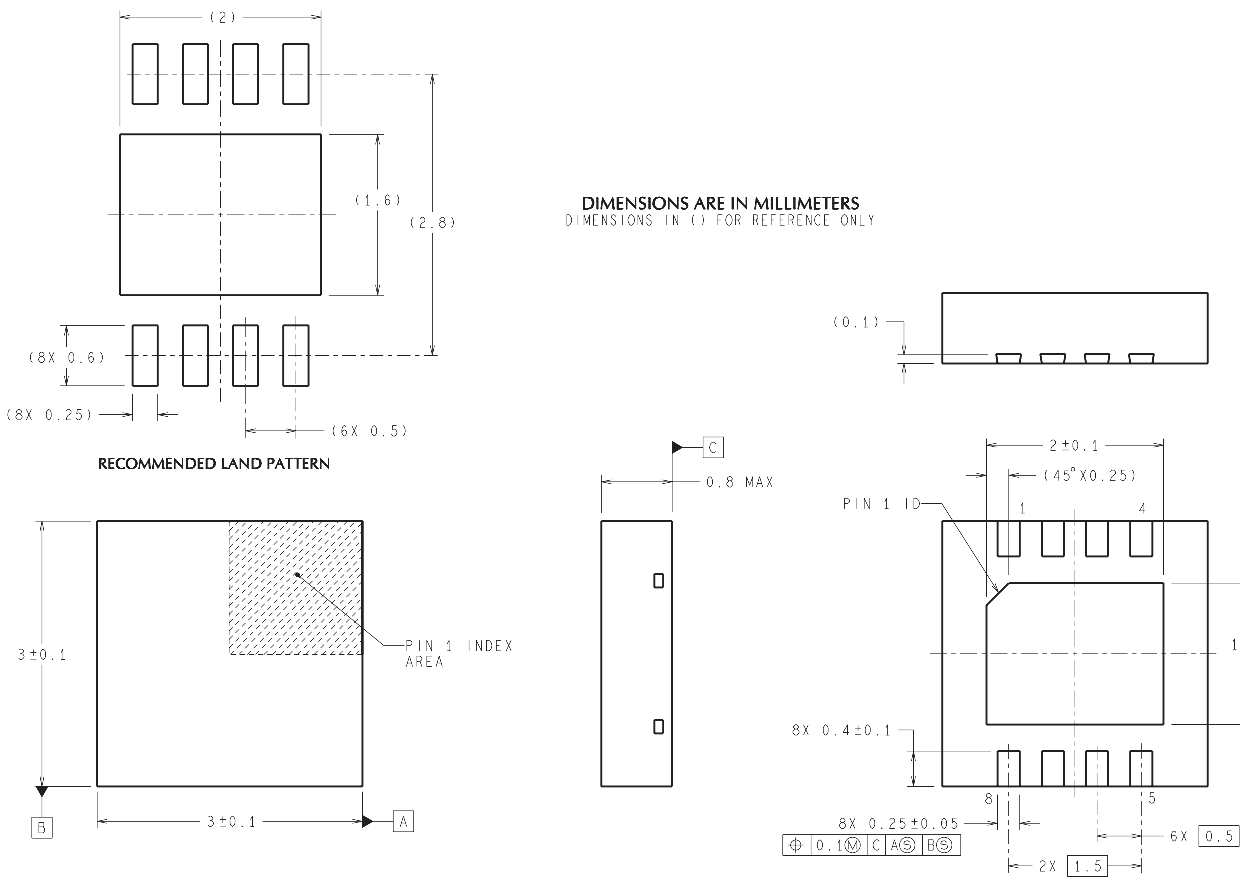
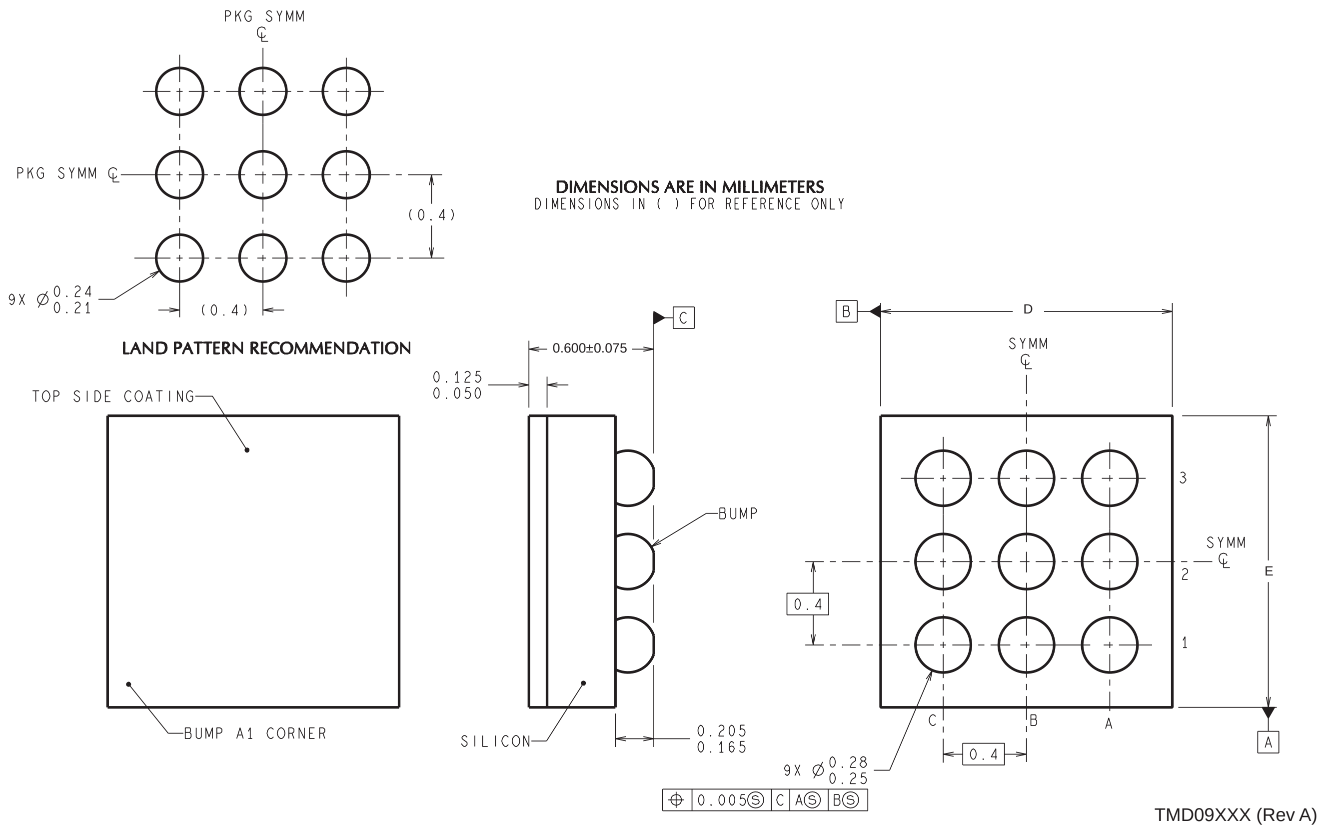
# NGQ0008A




SDA08A (Rev A)

# YFQ0009




D: Max = 1.417 mm, Min =1.316 mm

E: Max = 1.417 mm, Min =1.316 mm

4215077/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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