LM4674 Boomer® Audio Power Amplifier Series Filterless 2.5W Stereo Class D Audio Power Amplifier

1 Features

- Output Short Circuit Protection
- Stereo Class D Operation
- No Output Filter Required
- Logic Selectable Gain
- Independent Shutdown Control
- Minimum External Components
- Click and Pop Suppression
- Micro-Power Shutdown
- Available in Space-Saving 2mm x 2mm x 0.6mm DSBGA, and 4mm x 4mm x 0.8mm WQFN Packages

2 Applications

- Mobile Phones
- PDAs
- Laptops

3 Key Specifications

- Efficiency at 3.6V, 100mW into 8Ω: 80% (typ)
- Efficiency at 3.6V, 500mW into 8Ω: 85% (typ)
- Efficiency at 5V, 1W into 8Ω: 85% (typ)
- Quiescent Power Supply Current at 3.6V supply: 4mA
- Power Output at V_{DD} = 5V, R_L = 4Ω, THD ≤ 10%: 2.5W (typ)
- Shutdown Current: 0.03µA (typ)

4 DESCRIPTION

The LM4674 is a single supply, high efficiency, 2.5W/channel, filterless switching audio amplifier. A low noise PWM architecture eliminates the output filter, reducing external component count, board area consumption, system cost, and simplifying design.

The LM4674 is designed to meet the demands of mobile phones and other portable communication devices. Operating from a single 5V supply, the device is capable of delivering 2.5W/channel of continuous output power to a 4Ω load with less than 10% THD+N. Flexible power supply requirements allow operation from 2.4V to 5.5V.

The LM4674 features high efficiency compared to conventional Class AB amplifiers. When driving an 8Ω speaker from a 3.6V supply, the device features 85% efficiency at P_O = 500mW. Four gain options are pin selectable through the G0 and G1 pins.

Output short circuit protection prevents the device from being damaged during fault conditions. Click and pop suppression eliminates audible transients on power-up/down and during shutdown. Independent left/right shutdown control maximizes power savings in mixed mono/stereo applications.

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5 Pin Configuration and Functions

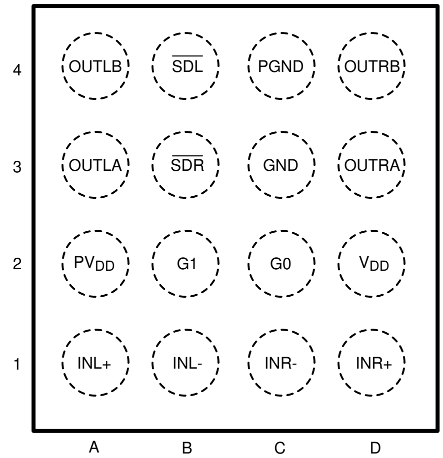


Figure 5-1. DSBGA (Top View)
See YZR0016 Package

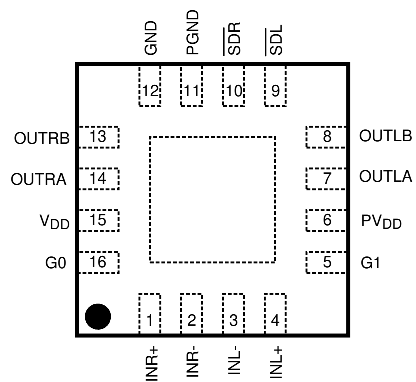


Figure 5-2. WQFN (Top View)
See RGH0016A Package

Table 5-1. Pin Attributes

BUMP	PIN	NAME	FUNCTION
A1	4	INL+	Non-inverting left channel input
A2	6	PV_{DD}	Power V_{DD}
A3	7	OUTLA	Left channel output A
A4	8	OUTLB	Left channel output B
B1	3	INL-	Inverting left channel input
B2	5	G1	Gain setting input 1
B3	10	$\overline{SDR}$	Right channel shutdown input
B4	9	$\overline{SDL}$	Left channel shutdown input
C1	2	INR-	Inverting right channel input
C2	16	G0	Gain setting input 0
C3	12	GND	Ground
C4	11	PGND	Power Ground
D1	1	INR+	Non-inverting right channel input
D2	15	V_{DD}	Power Supply

Table 5-1. Pin Attributes (continued)

BUMP	PIN	NAME	FUNCTION
D3	14	OUTRA	Right channel output A
D4	13	OUTRB	Right channel output B

6 Specifications

6.1 Absolute Maximum Ratings

Supply Voltage[(1)]		6.0V
Storage Temperature		−65°C to +150°C
Input Voltage		–0.3V to V_{DD} +0.3V
Power Dissipation[(2)]		Internally Limited
ESD Susceptibility, all other pins[(3)]		2000V
ESD Susceptibility[(4)]		200V
Junction Temperature (T_{JMAX})		150°C
Thermal Resistance	$θ_{JA}$ (DSBGA)	45.7°C/W
	$θ_{JA}$ (WQFN)	38.9°C/W

6.2 Operating Ratings

Temperature Range ($T_{MIN} ≤ T_A ≤ T_{MAX}$)	−40°C ≤ T_A ≤ 85°C
Supply Voltage	2.4V ≤ V_{DD} ≤ 5.5V

6.3 Electrical Characteristics V_{DD} = 3.6V

The following specifications apply for A_V = 6dB, R_L = 15µH + 8Ω + 15µH, f = 1kHz unless otherwise specified. Limits apply for T_A = 25°C.

Symbol	Parameter	Conditions	LM4674		Units (Limits)
			Typical[(5)]	Limit[(6) (7)]	
V_{OS}	Differential Output Offset Voltage	V_{IN} = 0, V_{DD} = 2.4V to 5.0V	5		mV
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0, R_L = ∞, Both channels active, V_{DD} = 3.6V	4	6	mA
		V_{IN} = 0, R_L = ∞, Both channels active, V_{DD} = 5V	5	7.5	mA
I_{SD}	Shutdown Current	$V_{\overline{SDR}} = V_{\overline{SDL}}$ = GND	0.03	1	µA
V_{SDIH}	Shutdown Voltage Input High			1.4	V (min)
V_{SDIL}	Shutdown Voltage Input Low			0.4	V (max)
T_{WU}	Wake Up Time	$V_{\overline{SDR}/\overline{SDL}}$ = 0.4V	0.5		ms
A_V	Gain	G0, G1 = GND R_L = ∞	6	6 ± 0.5	dB
		G0 = V_{DD}, G1 = GND R_L = ∞	12	12 ± 0.5	dB
		G0 = GND, G1 = V_{DD} R_L = ∞	18	18 ± 0.5	dB
		G0, G1 = V_{DD} R_L = ∞	24	24 ± 0.5	dB
R_{IN}	Input Resistance	A_V = 6dB	28		kΩ
		A_V = 12dB	18.75		kΩ
		A_V = 18dB	11.25		kΩ
		A_V = 24dB	6.25		kΩ

The following specifications apply for A_V = 6dB, R_L = 15μH + 8Ω + 15μH, f = 1kHz unless otherwise specified. Limits apply for T_A = 25°C.

Symbol	Parameter	Conditions	LM4674		Units (Limits)
			Typical[5]	Limit[6] [7]	
P_O	Output Power	R_L = 15μH + 4Ω + 15μH, THD ≤ 10% f = 1kHz, 22kHz BW			
		V_{DD} = 5V	2.5		W
		V_{DD} = 3.6V	1.2		W
		V_{DD} = 2.5V	0.530		W
		R_L = 15μH + 8Ω + 15μH, THD ≤ 10% f = 1kHz, 22kHz BW			
		V_{DD} = 5V	1.5		W
		V_{DD} = 3.6V	0.78	0.6	W
		V_{DD} = 2.5V	0.350		W
		R_L = 15μH + 4Ω + 15μH, THD ≤ 1% f = 1kHz, 22kHz BW			
		V_{DD} = 5V	1.9		W
		V_{DD} = 3.6V	1		W
		V_{DD} = 2.5V	0.430		W
		R_L = 15μH + 8Ω + 15μH, THD = 1% f = 1kHz, 22kHz BW			
		V_{DD} = 5V	1.25		W
		V_{DD} = 3.6V	0.63		W
		V_{DD} = 2.5V	0.285		W
THD+N	Total Harmonic Distortion	P_O = 500mW, f = 1kHz, RL = 8Ω	0.07		%
		P_O = 300mW, f = 1kHz, RL = 8Ω	0.05		%
PSRR	Power Supply Rejection Ratio	V_{RIPPLE} = 200mV_{P-P} Sine, f_{RIPPLE} = 217Hz, Inputs AC GND, C_i = 1μF, input referred	75		dB
		V_{RIPPLE} = 1V_{P-P} Sine, f_{RIPPLE} = 1kHz, Inputs AC GND, C_i = 1μF, input referred	75		dB
CMRR	Common Mode Rejection Ratio	V_{RIPPLE} = 1V_{P-P} f_{RIPPLE} = 217Hz	67		dB
η	Efficiency	P_O = 1W, f = 1kHz, R_L = 8Ω, V_{DD} = 5V	85		%
Xtalk	Crosstalk	P_O = 500mW, f = 1kHz	84		dB
SNR	Signal to Noise Ratio	V_{DD} = 5V, P_O = 1W	96		dB
ε_{OS}	Output Noise	Input referred, A-Weighted Filter	20		μV

(1) All voltages are measured with respect to the ground pin, unless otherwise specified.
(2) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{JMAX}, θ_{JA}, and the ambient temperature, T_A. The maximum allowable power dissipation is $P_{DMAX} = (T_{JMAX} - T_A)/\theta_{JA}$ or the number given in Absolute Maximum Ratings, whichever is lower. For the LM4674 see power derating currents for more information.
(3) Human body model, 100pF discharged through a 1.5kΩ resistor.
(4) Machine Model, 220pF–240pF discharged through all pins.
(5) Typicals are measured at 25°C and represent the parametric norm.
(6) Limits are specified to AOQL (Average Outgoing Quality Level).
(7) Datasheet min/max specification limits are specified by design, test, or statistical analysis.

6.4 Typical Performance Characteristics

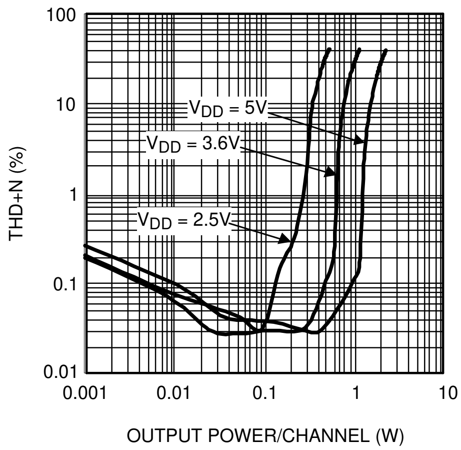


Figure 6-1. THD+N vs Output Power
f = 1kHz, A_V = 24dB, R_L = 8Ω

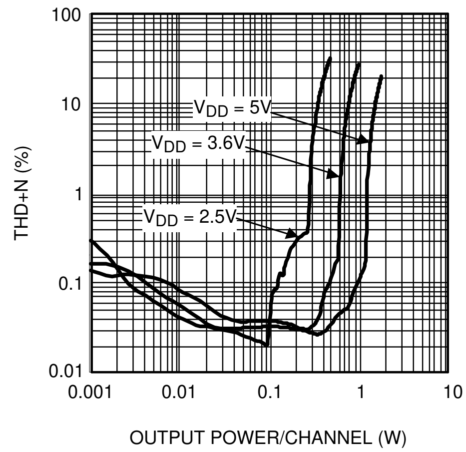


Figure 6-2. THD+N vs Output Power
f = 1kHz, A_V = 6dB, R_L = 8Ω

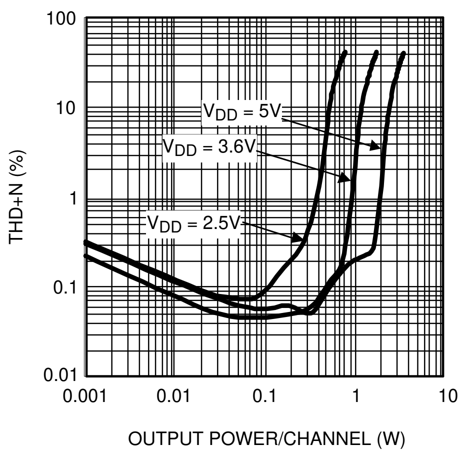


Figure 6-3. THD+N vs Output Power
f= 1kHz, A_V = 24dB, R_L = 4Ω

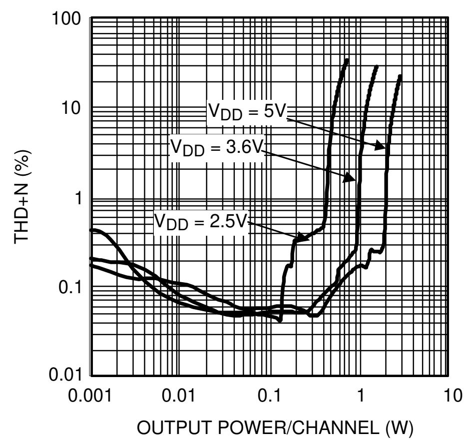


Figure 6-4. THD+N vs Output Power
f = 1kHz, A_V = 6dB, R_L = 4Ω

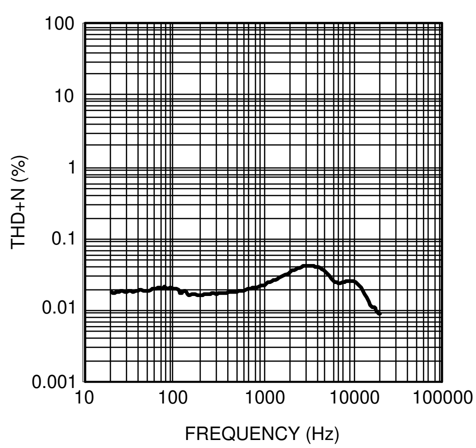


Figure 6-5. THD+N vs Frequency
V_{DD} = 2.5V, P_{OUT} = 100mW/ch, R_L = 8Ω

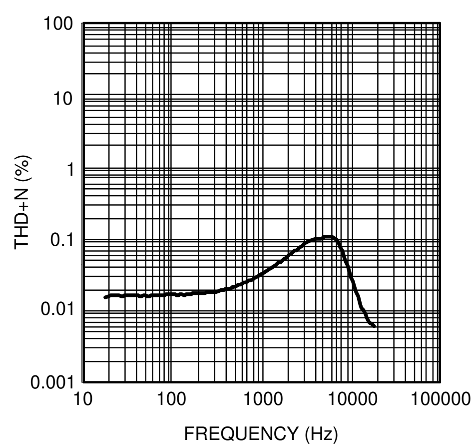


Figure 6-6. THD+N vs Frequency
V_{DD} = 3.6V, P_{OUT} = 250mW/ch, R_L = 8Ω

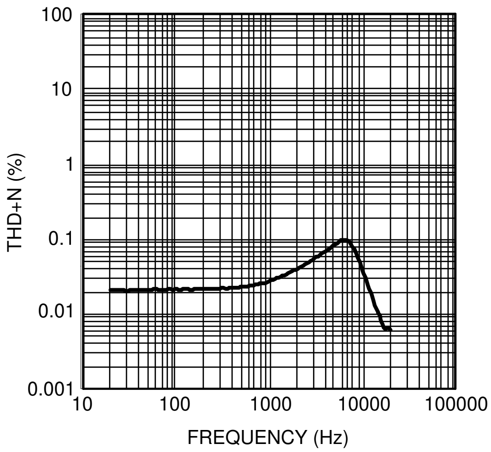


Figure 6-7. THD+N vs Frequency
V_{DD} = 5V, P_{OUT} = 375mW/ch, R_L = 8Ω

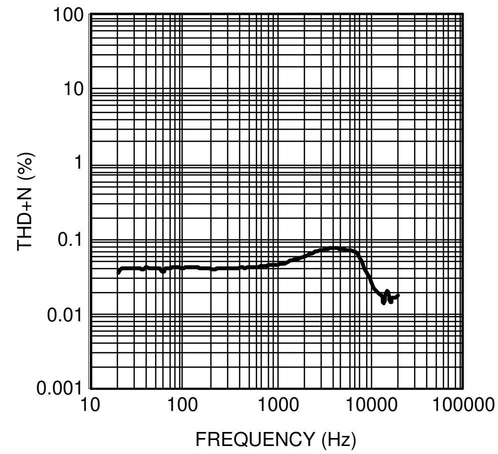


Figure 6-8. THD+N vs Frequency
V_{DD} = 2.5V, P_{OUT} = 100mW/ch, R_L = 4Ω

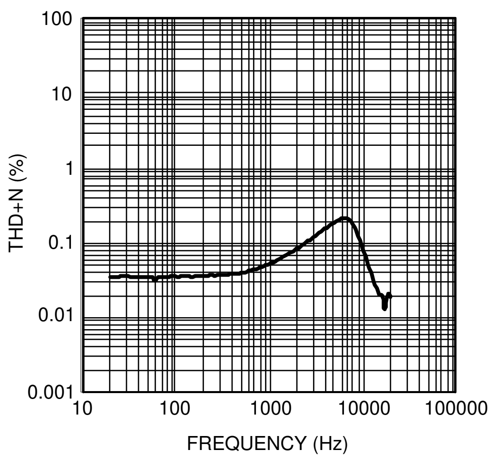


Figure 6-9. THD+N vs Frequency
V_{DD} = 3.6V, P_{OUT} = 250mW/ch, R_L = 4Ω

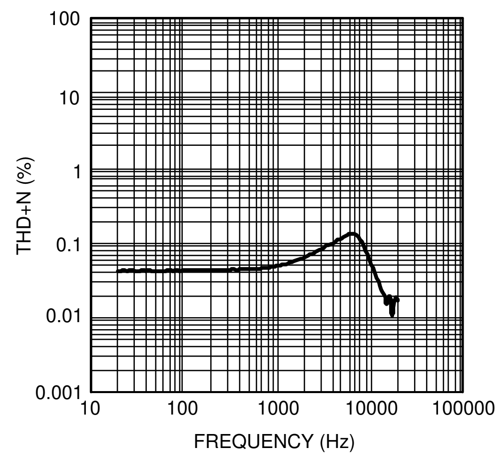


Figure 6-10. THD+N vs Frequency
V_{DD} = 5V, P_{OUT} = 375mW/ch, R_L = 4Ω

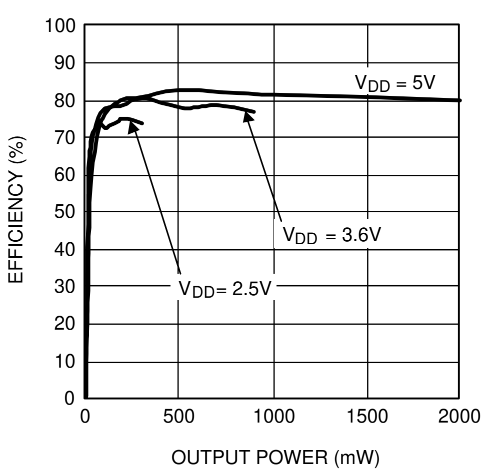


Figure 6-11. Efficiency vs Output Power/channel
R_L = 4Ω, f = 1kHz

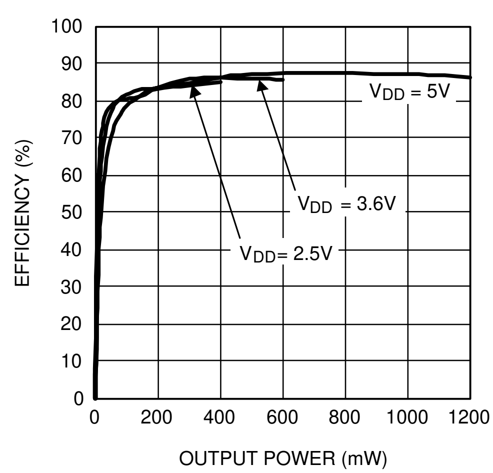


Figure 6-12. Efficiency vs Output Power/channel
R_L = 8Ω, f = 1kHz

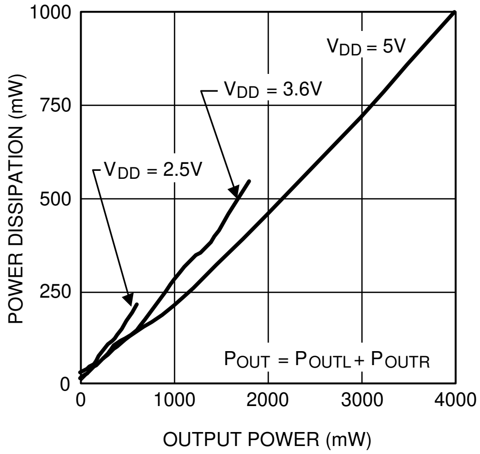


Figure 6-13. Power Dissipation vs Output Power $R_L = 4\Omega$, f = 1kHz

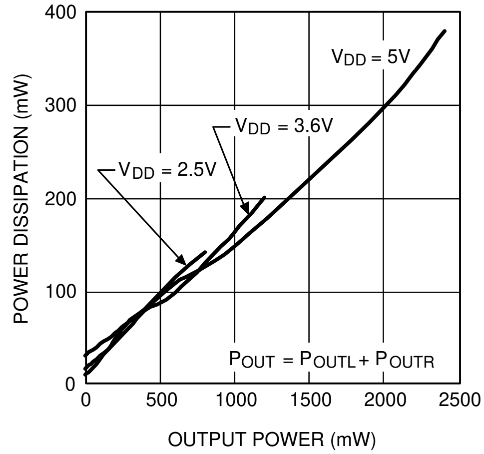


Figure 6-14. Power Dissipation vs Output Power $R_L = 8\Omega$, f = 1kHz

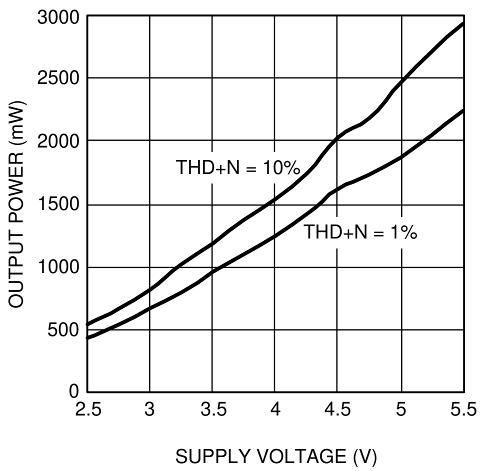


Figure 6-15. Output Power/channel vs Supply Voltage $R_L = 4\Omega$, f = 1kHz

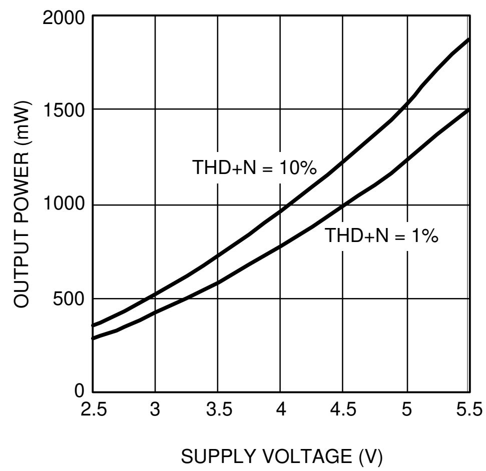


Figure 6-16. Output Power/channel vs Supply Voltage $R_L = 8\Omega$, f = 1kHz

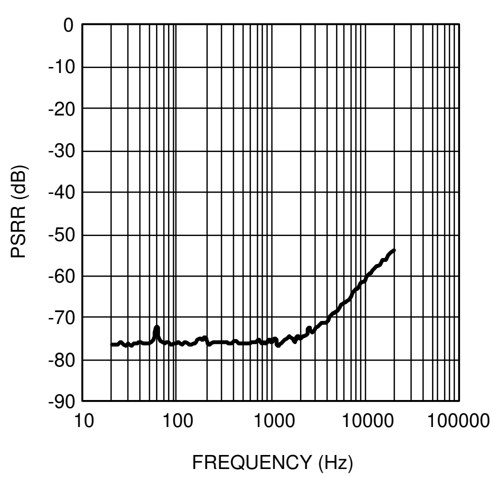


Figure 6-17. PSRR vs Frequency $V_{DD} = 3.6V$, $V_{RIPPLE} = 200mV_{P-P}$, $R_L = 8\Omega$

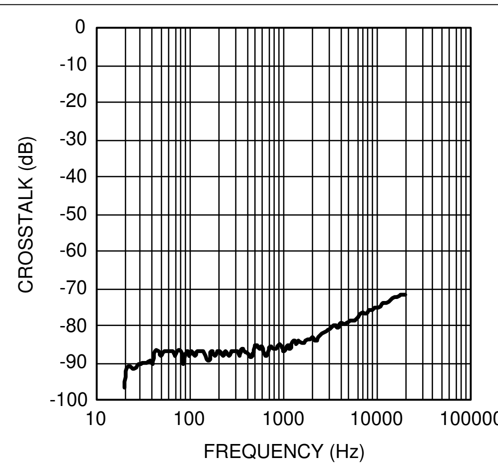


Figure 6-18. Crosstalk vs Frequency $V_{DD} = 3.6V$, $V_{RIPPLE} = 1V_{P-P}$, $R_L = 8\Omega$

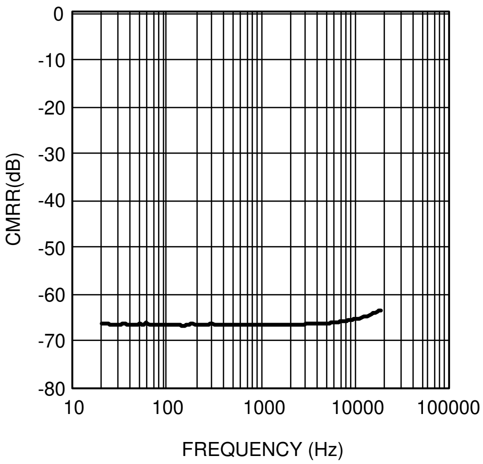


Figure 6-19. CMRR vs Frequency
V_{DD} = 3.6V, V_{CM} = 1V_{P-P}, R_L = 8Ω

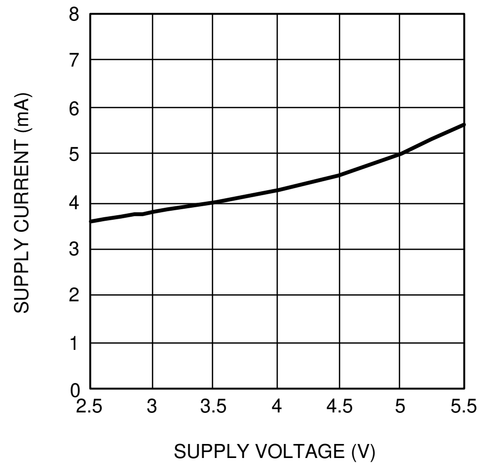


Figure 6-20. Supply Current vs Supply Voltage
R_L = ∞

7 Block Diagrams

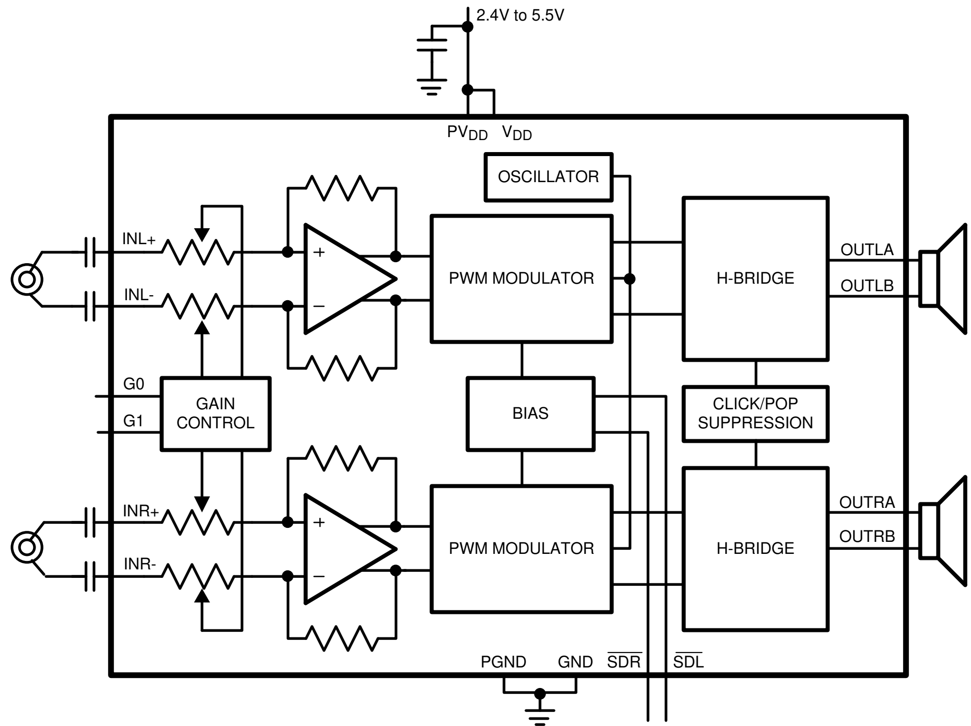


Figure 7-1. Differential Input Configuration

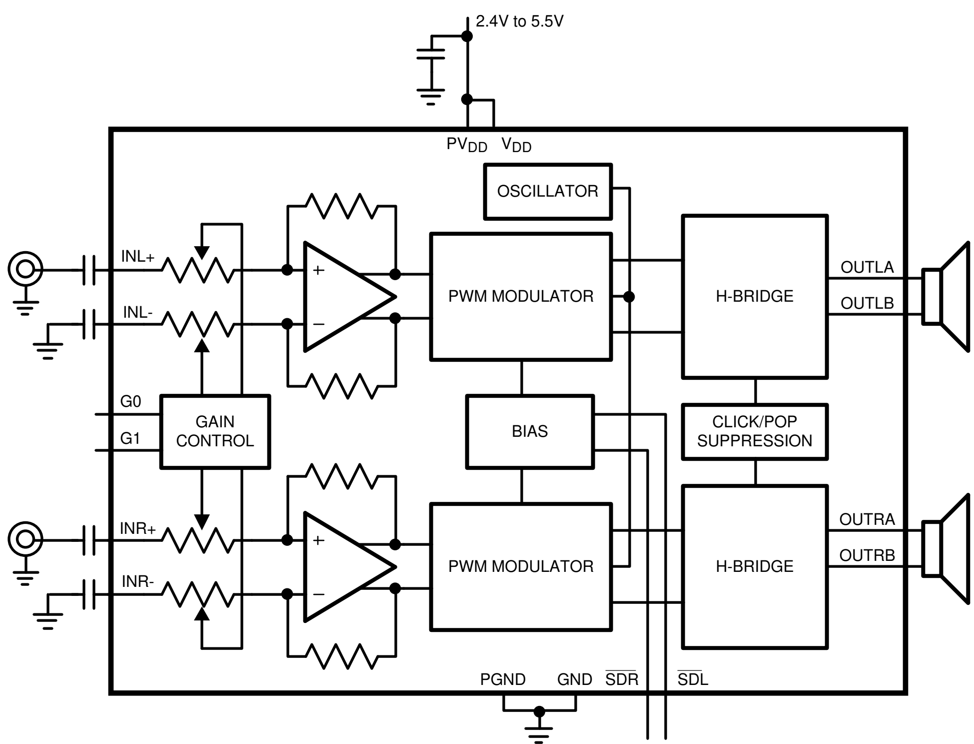


Figure 7-2. Single-Ended Input Configuration

8 Application Information

8.1 General Amplifier Function

The LM4674 stereo Class D audio power amplifier features a filterless modulation scheme that reduces external component count, conserving board space and reducing system cost. The outputs of the device transition from V_{DD} to GND with a 300kHz switching frequency. With no signal applied, the outputs for each channel switch with a 50% duty cycle, in phase, causing the two outputs to cancel. This cancellation results in no net voltage across the speaker, thus there is no current to the load in the idle state.

With the input signal applied, the duty cycle (pulse width) of the LM4674 outputs changes. For increasing output voltage, the duty cycle of the A output increases, while the duty cycle of the B output decreases for each channel. For decreasing output voltages, the converse occurs. The difference between the two pulse widths yields the differential output voltage.

8.2 Differential Amplifier Explanation

As logic supplies continue to shrink, system designers are increasingly turning to differential analog signal handling to preserve signal to noise ratios with restricted voltage signs. The LM4674 features two fully differential amplifiers. 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 of SNR relative to differential inputs. The LM4674 also offers the possibility of DC input coupling which eliminates the input coupling capacitors. A major benefit of the fully differential amplifier is the improved common mode rejection ratio (CMRR) over single ended input amplifiers. The increased CMRR of the differential amplifier reduces sensitivity to ground offset related noise injection, especially important in noisy systems.

8.3 Power Dissipation and Efficency

The major benefit of a Class D amplifier is increased efficiency versus a class AB amplifier. The efficiency of the LM4674 is attributed to the region of operation of the transistors in the output stage. The Class D output stage acts as current steering switches, consuming negligible amounts of power compared to their Class AB counterparts. Most of the power loss associated with the output stage is due to the IR loss of the MOSFET on-resistance ($R_{DS(ON)}$), along with switching losses due to gate charge.

8.4 Shutdown Function

The LM4674 features independent left and right channel shutdown controls, allowing each channel to be disabled independently. $\overline{SDR}$ controls the right channel, while $\overline{SDL}$ controls the left channel. Driving either low disables the corresponding channel.

It is best to switch between ground and V_{DD} for minimum current consumption while in shutdown. The LM4674 may be disabled with shutdown voltages in between GND and V_{DD}, the idle current will be greater than the typical 0.03µA value. For logic levels between GND and V_{DD} bypass $\overline{SD}$_ with a 0.1µF capacitor.

The LM4674 shutdown inputs have internal pulldown resistors. The purpose of these resistors is to eliminate any unwanted state changes when $\overline{SD}$_ is floating. To minimize shutdown current, $\overline{SD}$_ should be driven to GND or left floating. If $\overline{SD}$_ is not driven to GND or floating, an increase in shutdown supply current will be noticed.

8.5 Single-Ended Audio Amplifier Configuration

The LM4674 is compatible with single-ended sources. When configured for single-ended inputs, input capacitors must be used to block any DC component at the input of the device. Figure 7-2 shows the typical single-ended applications circuit.

8.6 Audio Amplifier Power Supply Bypassing/Filtering

Proper power supply bypassing is critical for low noise performance and high PSRR. Place the supply bypass capacitor as close to the device as possible. Typical applications employ a voltage regulator with 10µF and 0.1µF bypass capacitors that increase supply stability. These capacitors do not eliminate the need for bypassing of the LM4674 supply pins. A 1µF capacitor is recommended.

8.7 Audio Amplifier Input Capacitor Selection

Input capacitors is required for some applications, or when the audio source is single-ended. Input capacitors block the DC component of the audio signal, eliminating any conflict between the DC component of the audio source and the bias voltage of the LM4674. The input capacitors create a high-pass filter with the input resistance Ri. The -3dB point of the high pass filter is found using Equation 1 below.

$$f = 1 / 2\pi R_i C_i \quad (1)$$

The values for Ri can be found in the EC table for each gain setting.

The input capacitors can also be used to remove low frequency content from the audio signal. Small speakers cannot reproduce, and can even be damaged by low frequencies. High pass filtering the audio signal helps protect the speakers. When the LM4674 is using a single-ended source, power supply noise on the ground is seen as an input signal. Setting the high-pass filter point above the power supply noise frequencies, 217 Hz in a GSM phone, for example, filters out the noise such that it is not amplified and heard on the output. Capacitors with a tolerance of 10% or better are recommended for impedance matching and improved CMRR and PSRR.

8.8 Audio Amplifier Gain Setting

The LM4674 features four internally configured gain settings. The device gain is selected through the two logic inputs, G0 and G1. The gain settings are as shown in the following table.

LOGIC INPUT		GAIN	
G1	G0	V/V	dB
0	0	2	6
0	1	4	12
1	0	8	18
1	1	16	24

8.9 Output Filter Considerations

One important aspect of the ferrite bead selection is the type of material used in the ferrite bead. Not all ferrite material is alike, selecting a material that is effective in the 10 to 100MHz range is important and key to the operation of the Class-D amplifier. Many of the specifications regulating consumer electronics have emissions limits as low as 30Hz. Using the ferrite bead filter to block radiation in the 30MHz and above range from appearing on the speaker wires and the power supply lines which are good antennas for these signals is important. The impedance of the ferrite bead can be used along with a small capacitor with a value in the range of 1000pF to reduce the frequency spectrum of the signal to an acceptable level. For best performance, the resonant frequency of the ferrite bead and capacitor filter is less than 10MHz.

Establish that the ferrite bead is large enough to maintain impedance at the peak currents expected for the amplifier. Some ferrite bead manufacturers specify the bead impedance at a variety of current levels. Whenever possible, make sure the ferrite bead maintains an adequate amount of impedance at the peak current that the amplifier detects. If these specifications are not available, estimating the bead current handling capability by measuring the resonant frequency of the filter output at low power and at maximum power is possible. A change of resonant frequency of less than fifty percent under this condition is desirable.

A high-quality ceramic capacitor is also required for the ferrite bead filter. A low ESR capacitor with good temperature and voltage characteristics works best.

Additional EMC improvements is obtained by adding snubber networks from each of the Class-D output to ground. Suggested values for a simple RC series snubber network is 68Ω in series with a 100pF capacitor although design of the snubber network is specific to every application and must be designed taking into account the parasitic reactance of the printed circuit board and the audio amplifier. Take care to evaluate the stress on the components in the snubber network especially if the amp is running at high PVCC. Also, make sure the layout of the snubber network is tight and returns directly to the GND or the thermal pad beneath the chip.

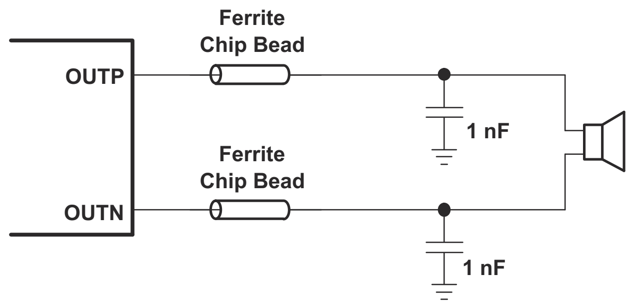


Figure 8-1. Typical Ferrite Chip Bead Filter (Chip Bead Example: NFZ2MSM series from Murata)

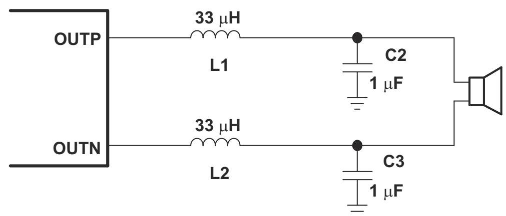


Figure 8-2. Typical LC Output Filter, Cutoff Frequency of 27kHz, Speaker Impedance = 8Ω

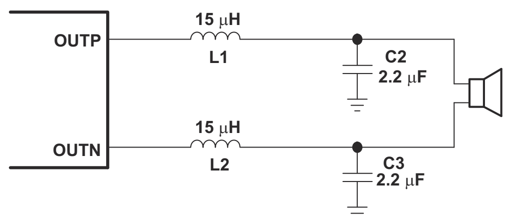


Figure 8-3. Typical LC Output Filter, Cutoff Frequency of 27kHz, Speaker Impedance = 6Ω

8.10 Layout Guidelines

As output power increases, interconnect resistance (PCB traces and wires) between the amplifier, load and power supply create a voltage drop. The voltage loss due to the traces between the LM4674 and the load results in lower output power and decreased efficiency. Higher trace resistance between the supply and the LM4674 has the same effect as a poorly regulated supply, increasing ripple on the supply line, and reducing 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. In addition to reducing trace resistance, the use of power planes creates parasitic 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 VDD 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. In is essential to keep the power and output traces short and well shielded if possible. Use of ground planes beads and micros-strip layout techniques are all useful in preventing unwanted interference.

As the distance from the LM4674 and the speaker increases, the amount of EMI radiation increases due to the output wires or traces acting as antennas become more efficient with length. Ferrite chip inductors places close to the LM4674 outputs may be needed to reduce EMI radiation.

8.11 LM4674TL Demo Board Schematic

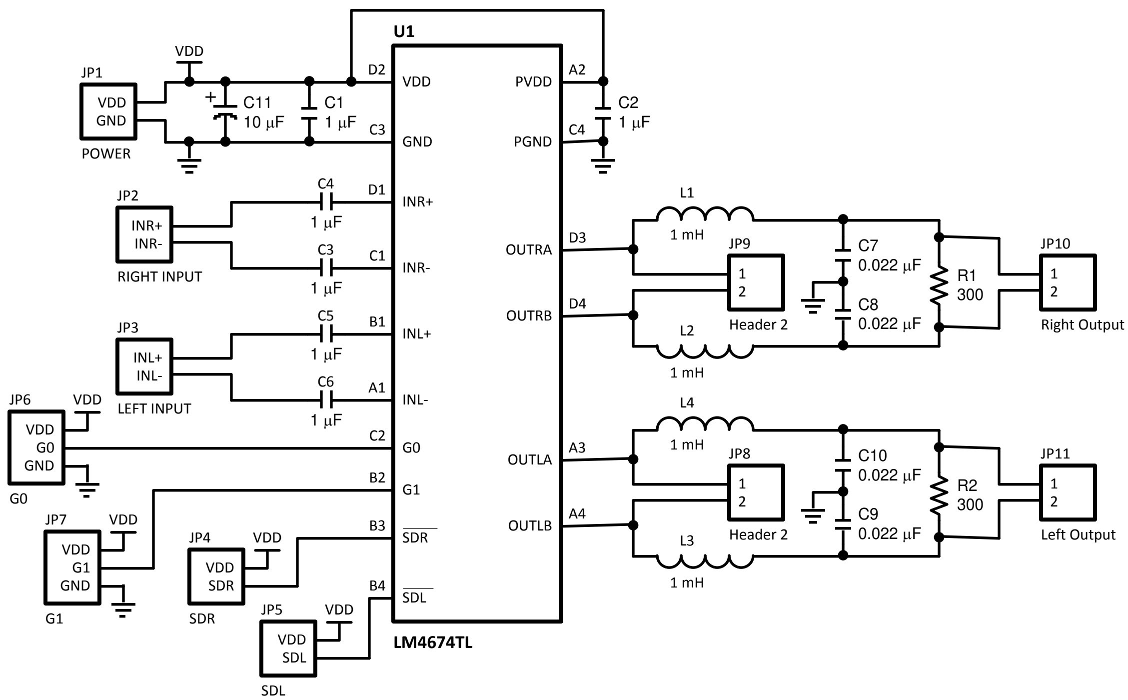


Figure 8-4. LM4674TL Demo Board Schematic

8.12 LM4674TL Demonstration Board Layout

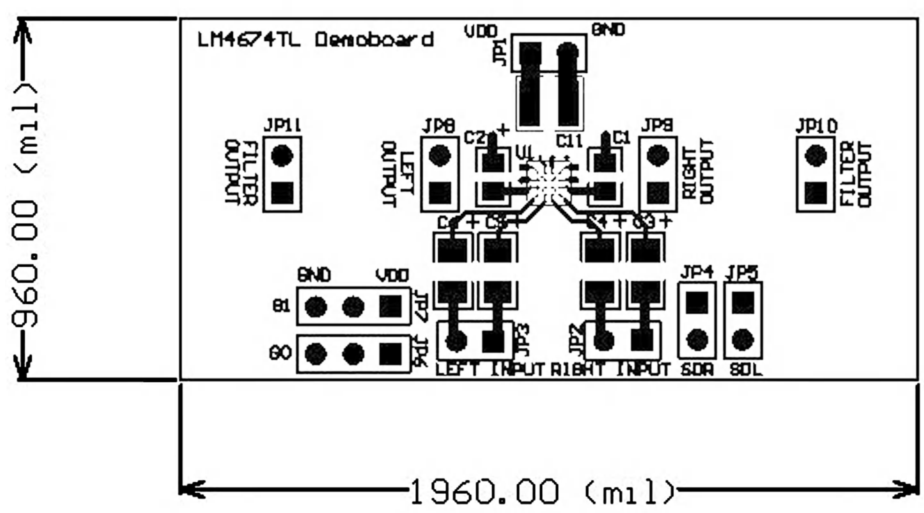


Figure 8-5. Layer 1

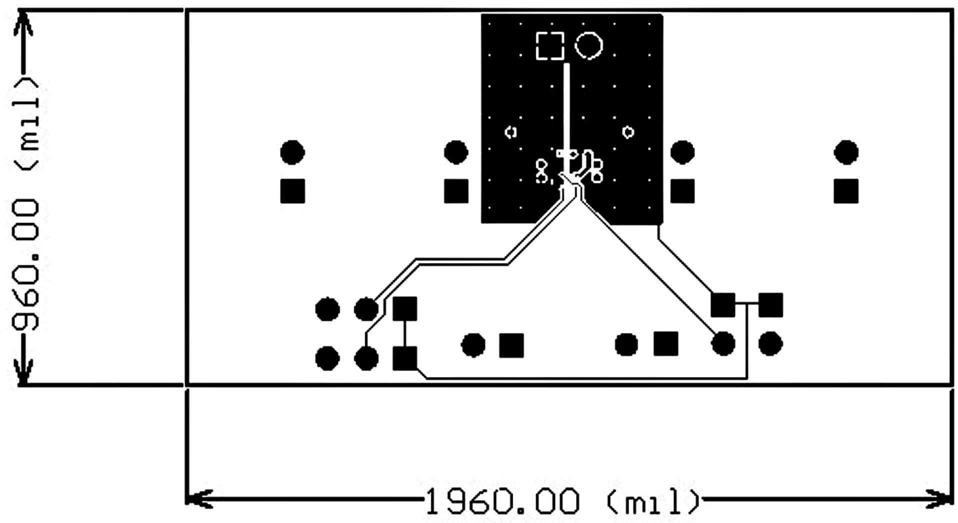


Figure 8-6. Layer 2

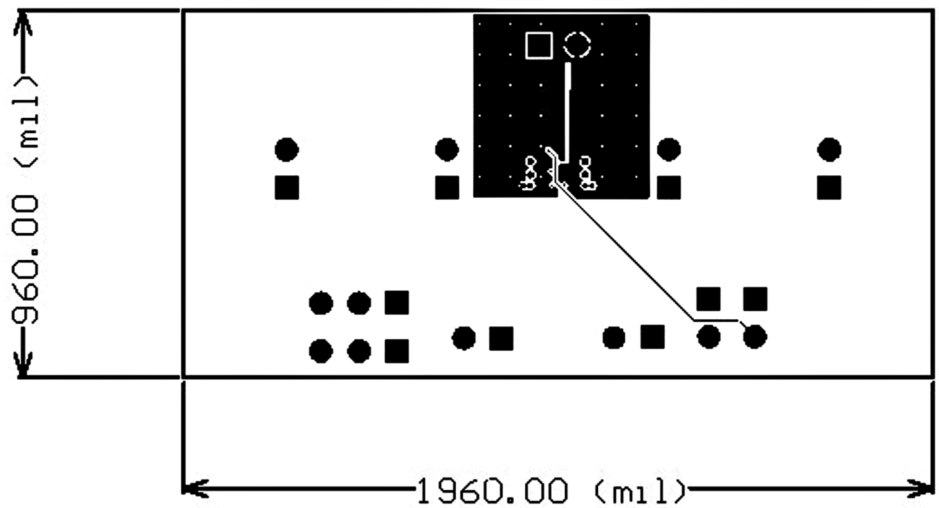


Figure 8-7. Layer 3

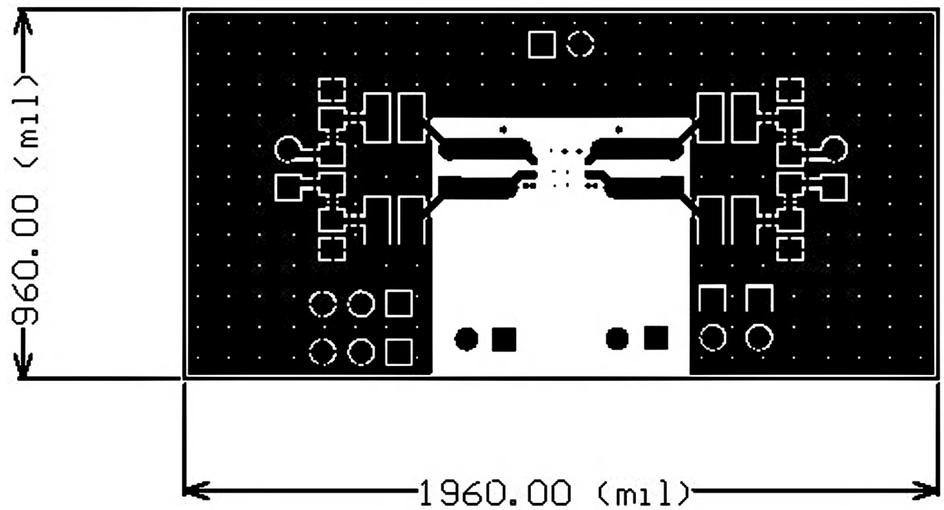


Figure 8-8. Layer 4

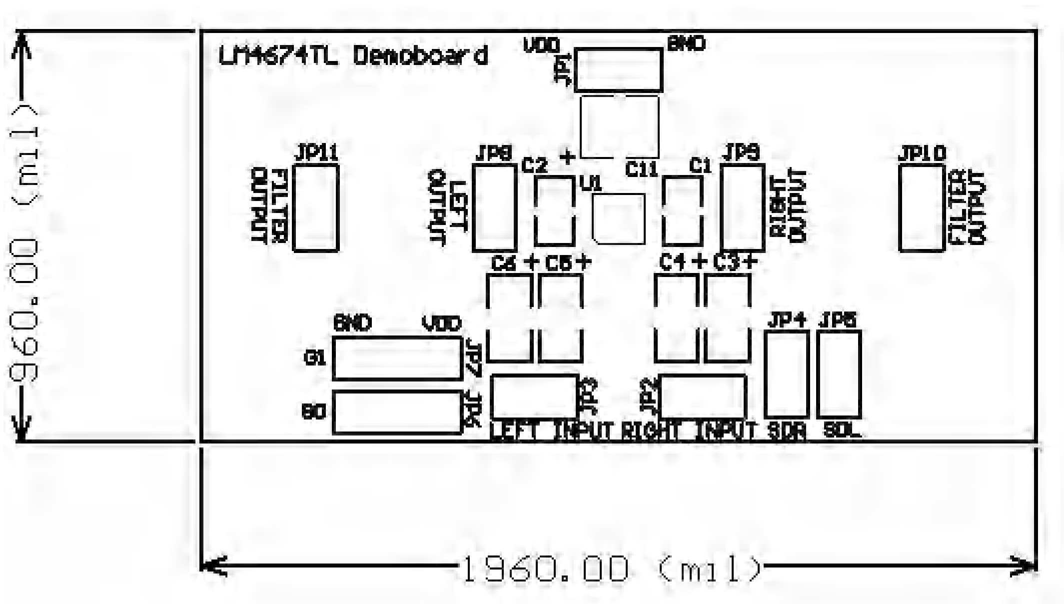


Figure 8-9. Top Silkscreen

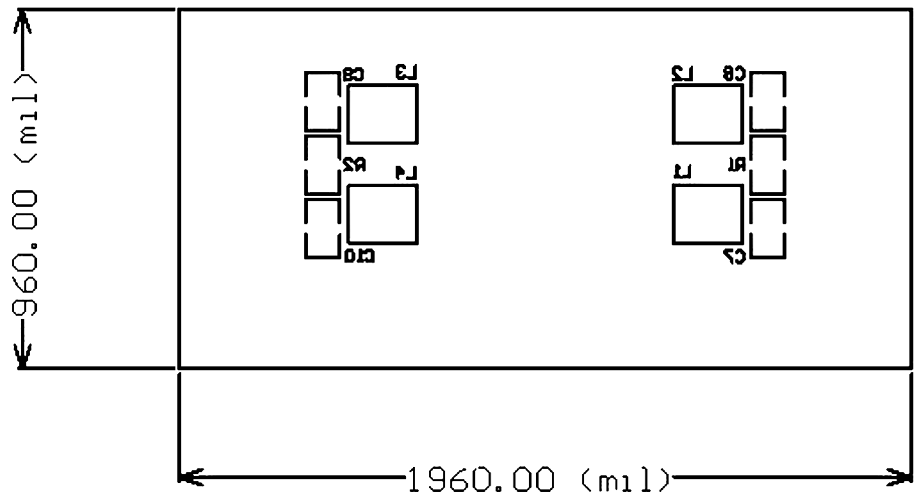


Figure 8-10. Bottom Silkscreen

8.13 LM4674SQ Demo Board Schematic

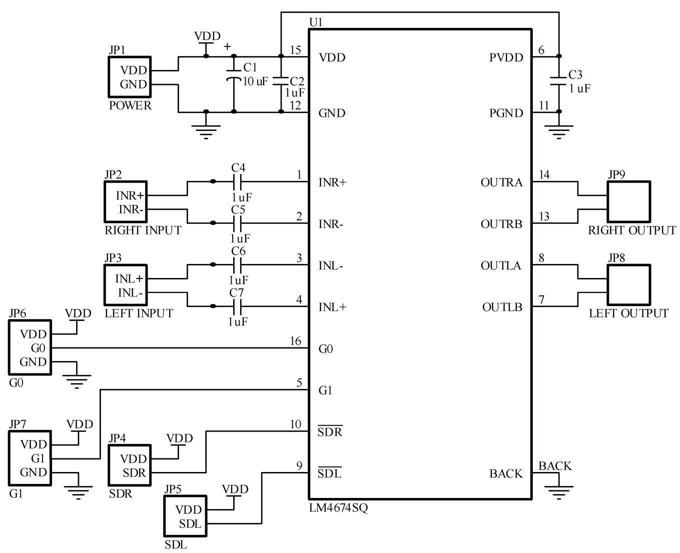


Figure 8-11. LM4674SQ Demo Board Schematic

8.14 LM4674SQ Demonstration Board Layout

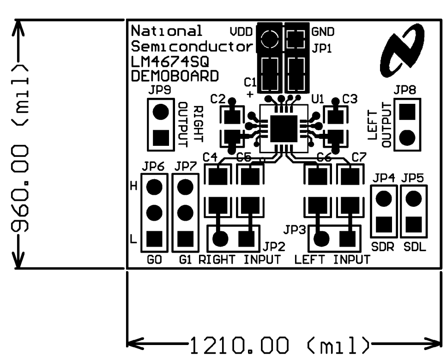


Figure 8-12. Layer 1

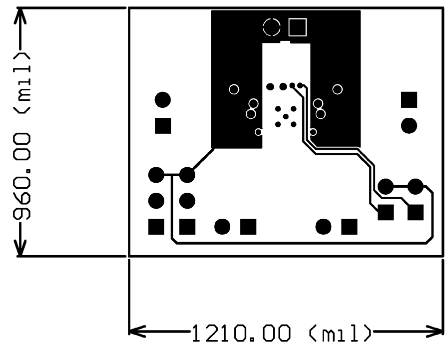


Figure 8-13. Layer 2

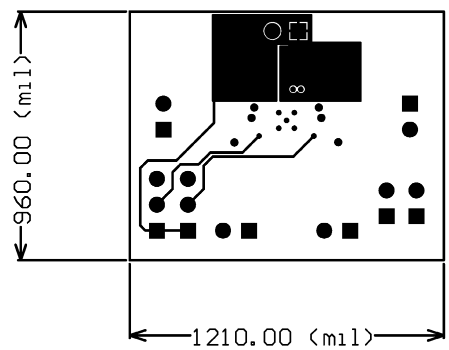


Figure 8-14. Layer 3

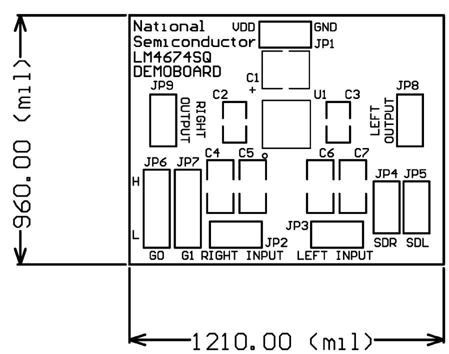


Figure 8-15. Top Silkscreen

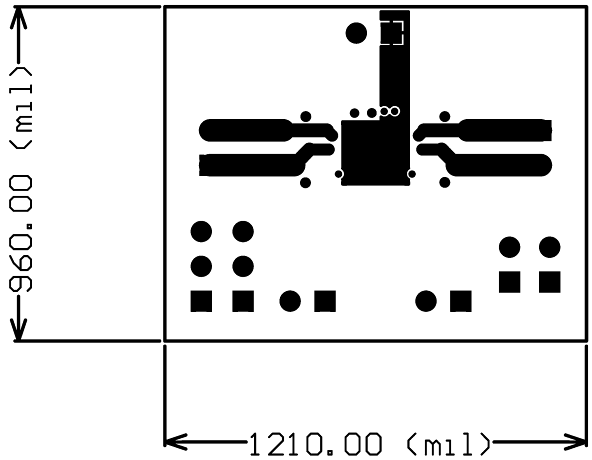
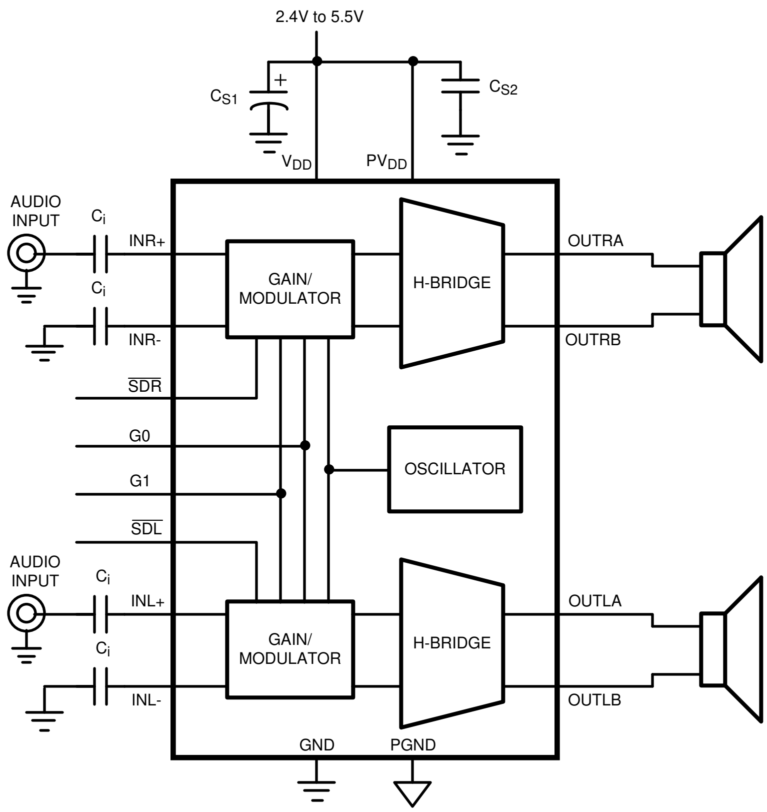


Figure 8-16. Bottom Layer

8.15 Trademarks

All trademarks are the property of their respective owners.

9 Typical Application



C_i = 1µF
C_{S1} = 1µF
C_{S2} = 0.1µF

Figure 9-1. Typical Audio Amplifier Application Circuit

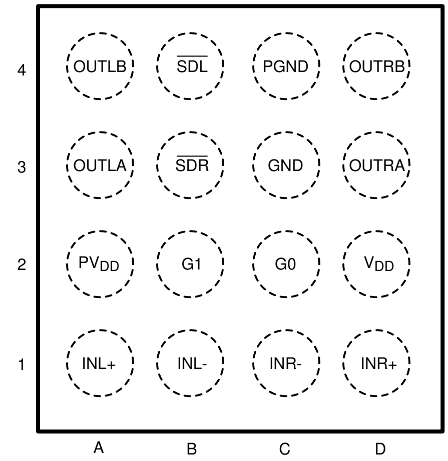


Figure 9-2. DSBGA (Top View)
See YZR0016 Package

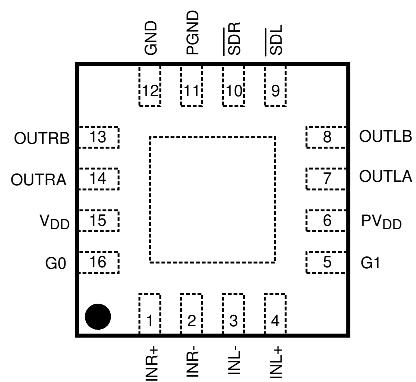


Figure 9-3. WQFN (Top View)
See RGH0016A Package

(Figure 9-1)

Components		Functional Description
1.	C_S	Supply bypass capacitor which provides power supply filtering. Refer to the Section 8.7 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.

10 Development Support

For development support on this product, see the following:

-

10.1 Third-Party Products Disclaimer

TI'S PUBLICATION OF INFORMATION REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE AN ENDORSEMENT REGARDING THE SUITABILITY OF SUCH PRODUCTS OR SERVICES OR A WARRANTY, REPRESENTATION OR ENDORSEMENT OF SUCH PRODUCTS OR SERVICES, EITHER ALONE OR IN COMBINATION WITH ANY TI PRODUCT OR SERVICE.

10.2 Device Nomenclature Boilerplate

Device development evolutionary flow:

X Experimental device that is not necessarily representative of the final device's electrical specifications and may not use production assembly flow.

P Prototype device that is not necessarily the final silicon die and may not necessarily meet final electrical specifications.

null Production version of the silicon die that is fully qualified.

Support tool development evolutionary flow:

TMDX Development-support product that has not yet completed Texas Instruments internal qualification testing.

TMDS Fully-qualified development-support product.

X and P devices and TMDX development-support tools are shipped against the following disclaimer:

Device development evolutionary flow:

TMX Experimental device that is not necessarily representative of the final device's electrical specifications and may not use production assembly flow.

TMP Prototype device that is not necessarily the final silicon die and may not necessarily meet final electrical specifications.

TMS Production version of the silicon die that is fully qualified.

Support tool development evolutionary flow:

TMDX Development-support product that has not yet completed Texas Instruments internal qualification testing.

TMDS Fully-qualified development-support product.

TMX and TMP devices and TMDX development-support tools are shipped against the following disclaimer:

"Developmental product is intended for internal evaluation purposes."

Production devices and TMDS development-support tools have been characterized fully, and the quality and reliability of the device have been demonstrated fully. TI's standard warranty applies.

Predictions show that prototype devices (X or P) have a greater failure rate than the standard production devices. Texas Instruments recommends that these devices not be used in any production system because their expected end-use failure rate still is undefined. Only qualified production devices are to be used.

11 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

12 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

13 Glossary

TI Glossary	This glossary lists and explains terms, acronyms, and definitions.

14 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision E (April 2013) to Revision F (August 2025) — **Page**

15 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LM4674SQ/NOPB	Active	Production	WQFN (RGH) | 16	1000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 85	L4674SQ
LM4674SQ/NOPB.A	Active	Production	WQFN (RGH) | 16	1000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 85	L4674SQ
LM4674TLX/NOPB	Active	Production	DSBGA (YZR) | 16	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	GG2
LM4674TLX/NOPB.A	Active	Production	DSBGA (YZR) | 16	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	GG2

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

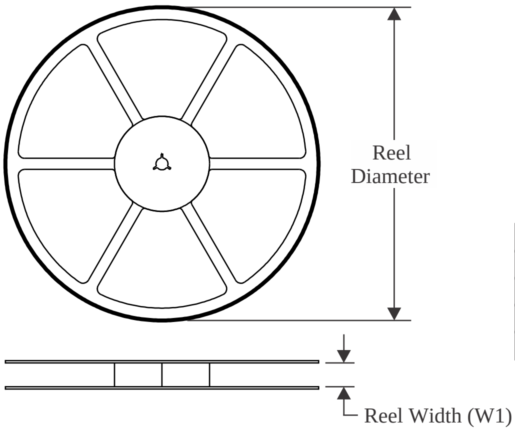
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

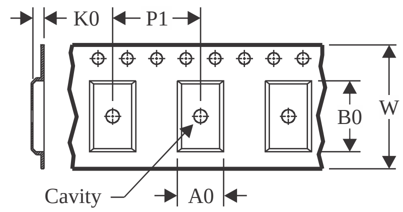
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

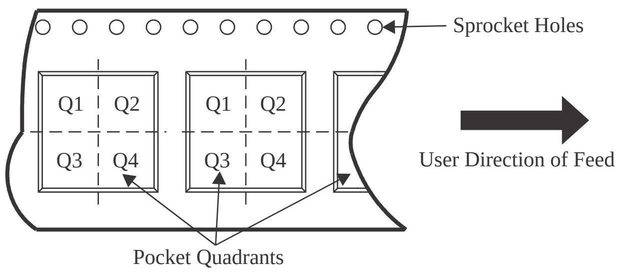


TAPE DIMENSIONS



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

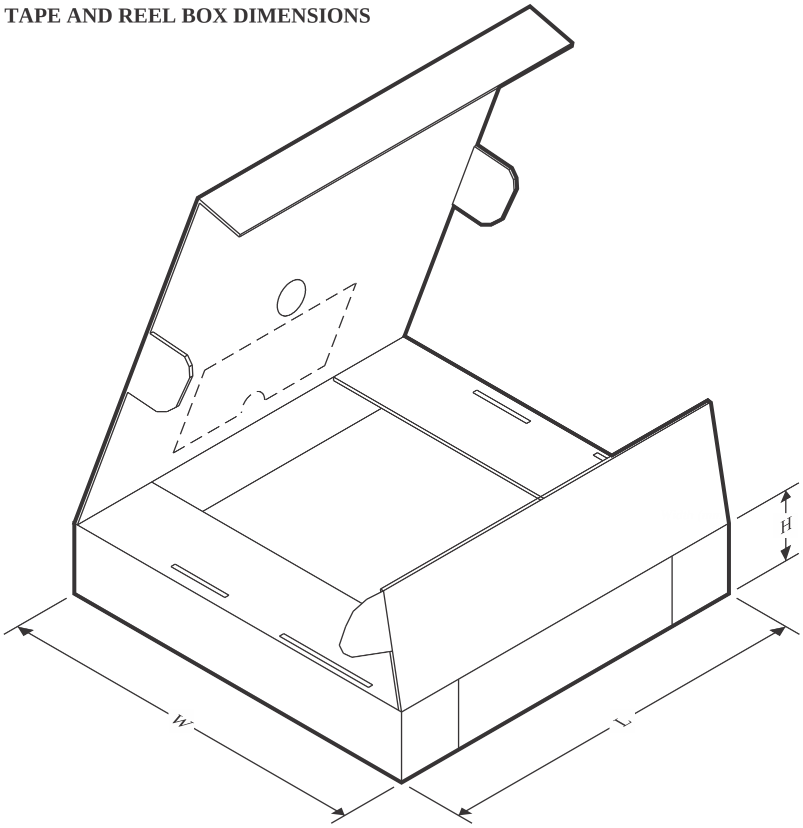
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

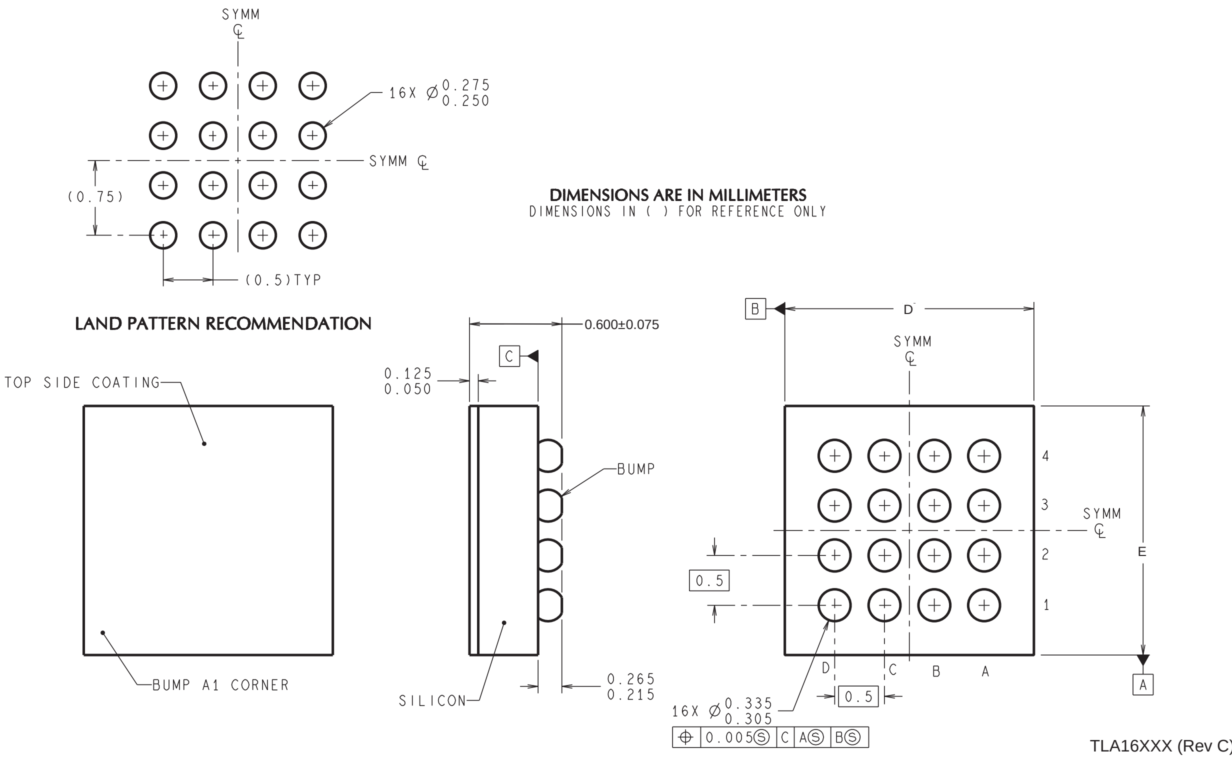
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM4674SQ/NOPB	WQFN	RGH	16	1000	177.8	12.4	4.3	4.3	1.3	8.0	12.0	Q1
LM4674TLX/NOPB	DSBGA	YZR	16	3000	178.0	8.4	2.08	2.08	0.76	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

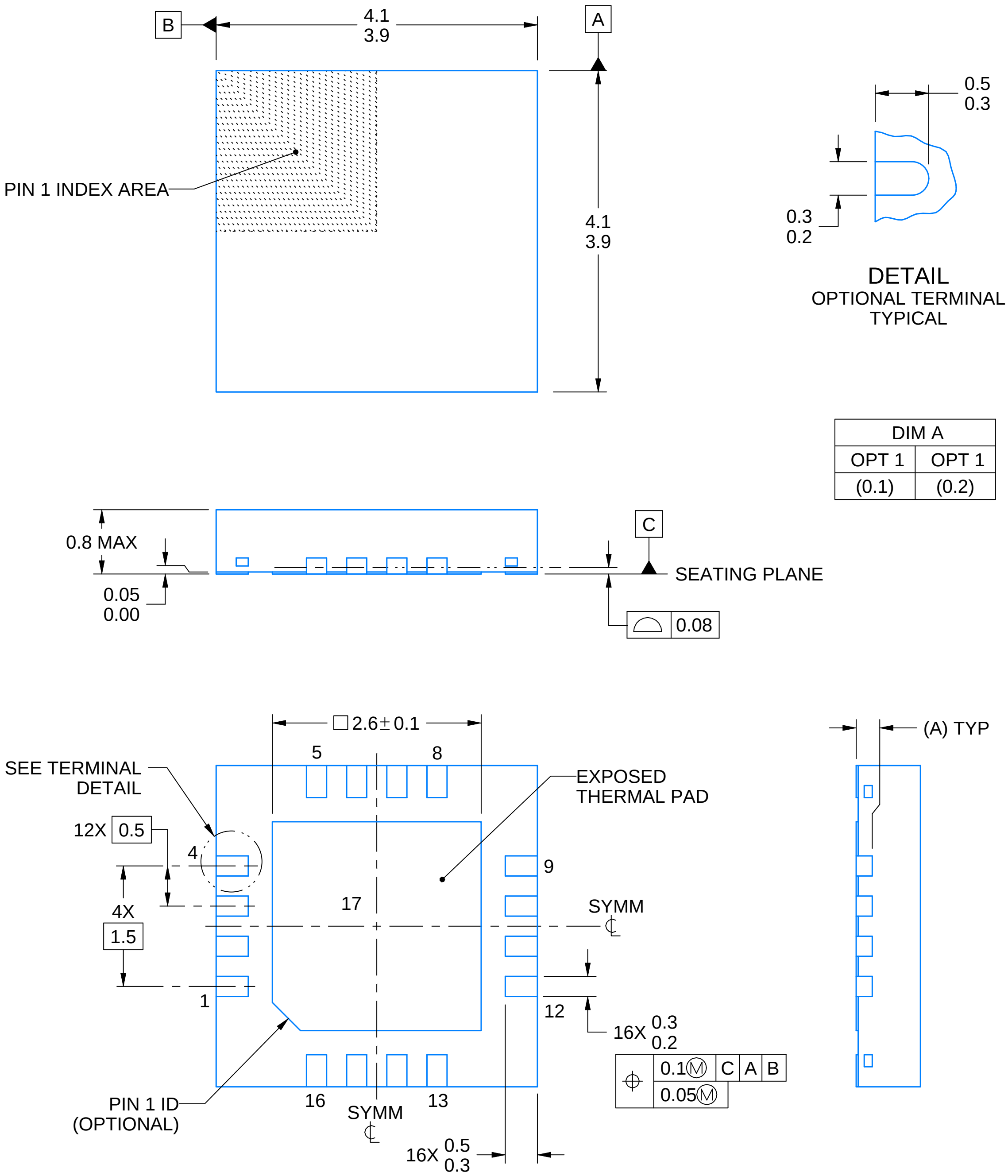
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM4674SQ/NOPB	WQFN	RGH	16	1000	208.0	191.0	35.0
LM4674TLX/NOPB	DSBGA	YZR	16	3000	208.0	191.0	35.0



D: Max = 1.99 mm,	Min = 1.93 mm
E: Max = 1.99 mm,	Min = 1.93 mm

4215051/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.

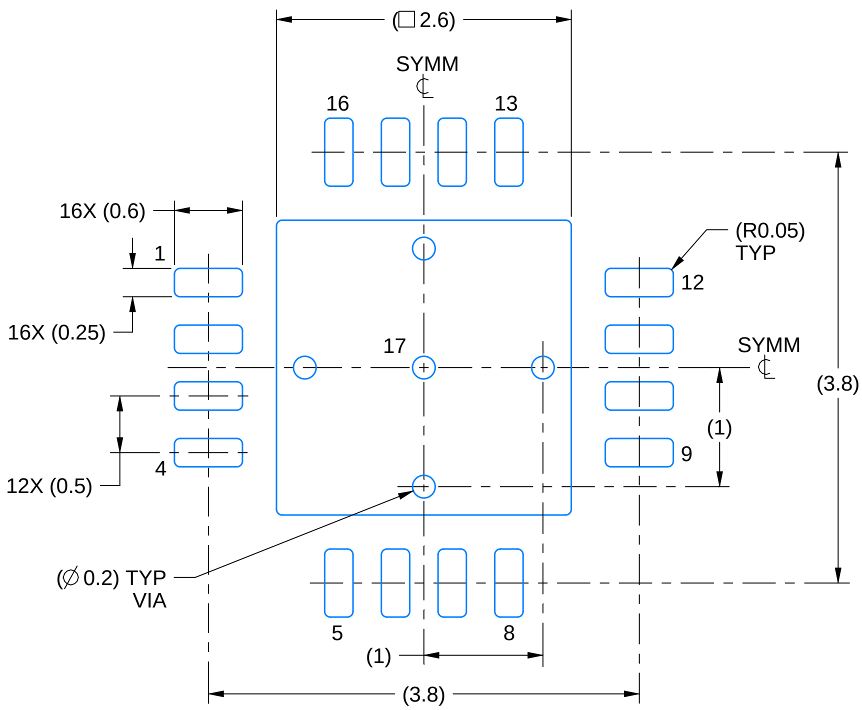


DIM A	
OPT 1	OPT 1
(0.1)	(0.2)

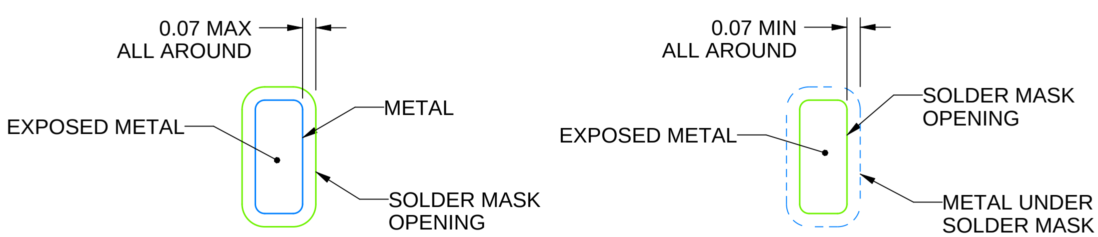
4214978/B 01/2017

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



NON SOLDER MASK
DEFINED
(PREFERRED)

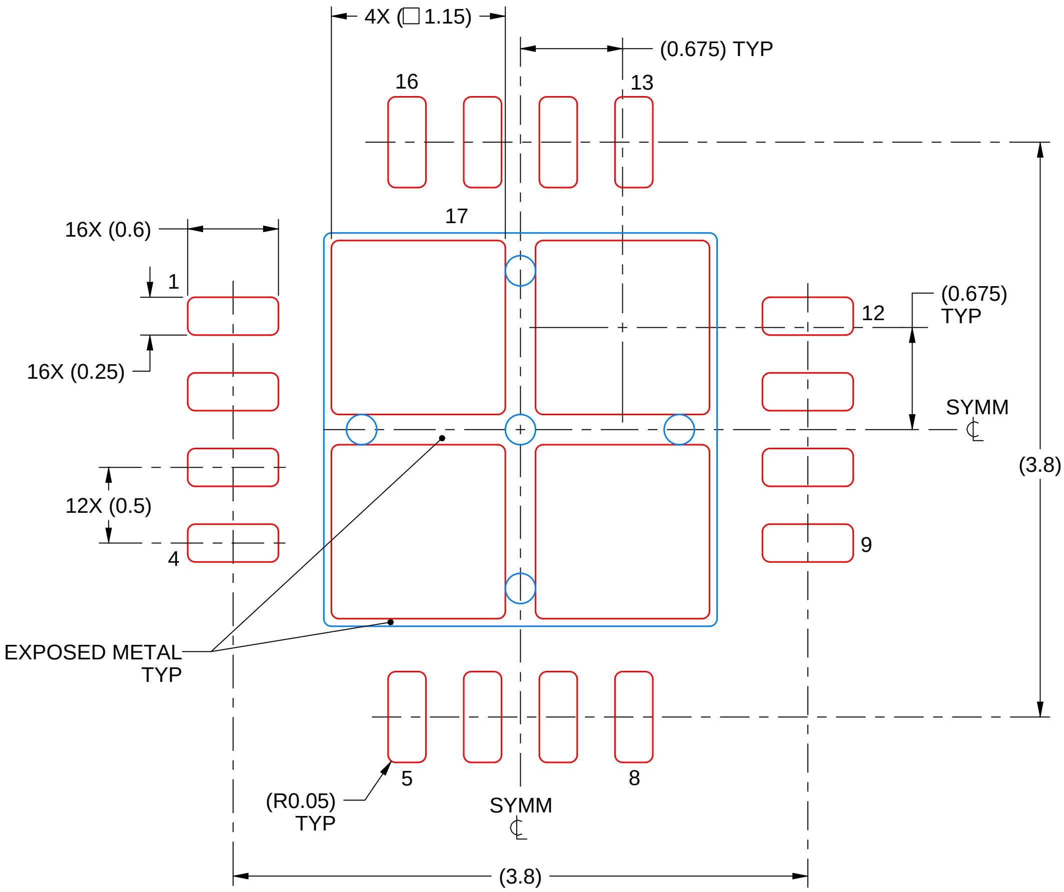
SOLDER MASK
DEFINED

SOLDER MASK DETAILS

4214978/B 01/2017

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 17
78% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:20X

4214978/B 01/2017

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.