LM4674A Boomer® Audio Power Amplifier Series Filterless 2.5W Stereo Class D Audio Power Amplifier

Check for Samples: LM4674A

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 Package**

APPLICATIONS

- **Mobile Phones**
- **PDAs**
- **Laptops**

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)**
- **Power Output at V_{DD} = 5V, R_L = 8Ω, THD ≤ 10% 1.5W (typ)**
- **Shutdown Current 0.1µA (typ)**

DESCRIPTION

The LM4674A 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 LM4674A 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 LM4674A 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 GAIN0 and GAIN1 pins.

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

Typical Application

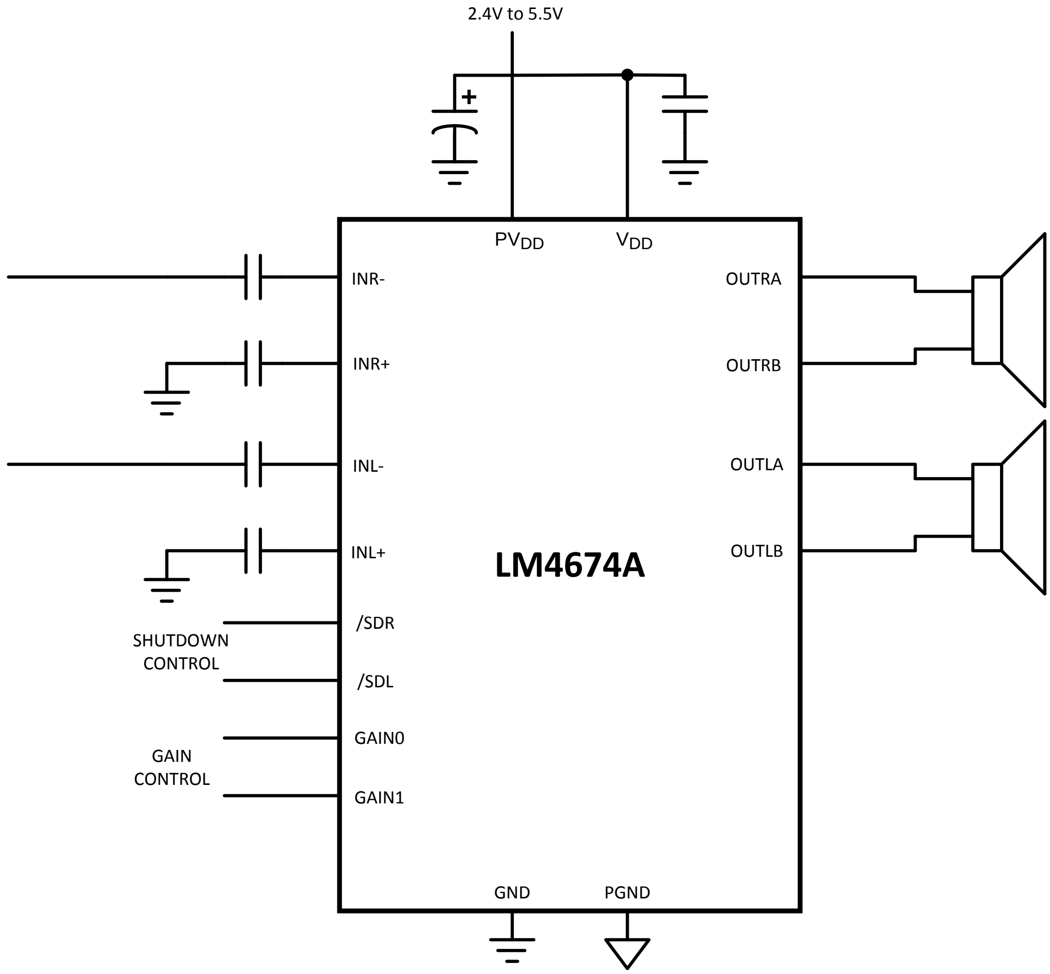


Figure 1. Typical Audio Amplifier Application Circuit

Connection Diagram

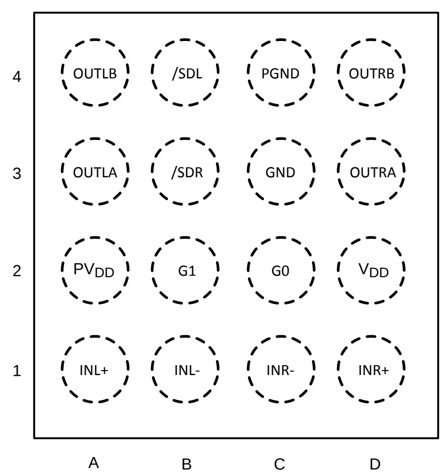


Figure 2. DSBGA - Top View
See YZR0016 Package

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
Input Voltage		–0.3V to V_{DD} +0.3V
Power Dissipation(4)		Internally Limited
ESD Susceptibility, all other pins(5)		2000V
ESD Susceptibility(6)		200V
Junction Temperature (T_{JMAX})		150°C
Thermal Resistance	θ_{JA}	45.7°C/W

(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 ensure specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which ensure specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not ensured 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}, 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 LM4674A see power derating currents for more information.
(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 ensure specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which ensure specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not ensured for parameters where no limit is given, however, the typical value is a good indication of device performance.

Electrical Characteristics V_{DD} = 3.6V[(1)(2)]

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	LM4674A		Units (Limits)
			Typical[(3)]	Limit[(4)]	
V_{OS}	Differential Output Offset Voltage	V_{IN} = 0, V_{DD} = 2.4V to 5.0 V	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_{SD1} = V_{SD2} = 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	$V_{SHUTDOWN}$ = 0.4V	4.2		ms
A_V	Gain	GAIN0, GAIN1 = GND	6	6 ± 0.5	dB
		GAIN0 = V_{DD}, GAIN1 = GND	12	12 ± 0.5	dB
		GAIN0 = GND, GAIN1 = V_{DD}	18	18 ± 0.5	dB
		GAIN0, GAIN1 = V_{DD}	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
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		%

(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 ensure specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which ensure specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not ensured for parameters where no limit is given, however, the typical value is a good indication of device performance.
(3) Typicals are measured at 25°C and represent the parametric norm.
(4) Limits are specified to TI's AOQL (Average Outgoing Quality Level).

Electrical Characteristics V_{DD} = 3.6V[1][2] (continued)

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.

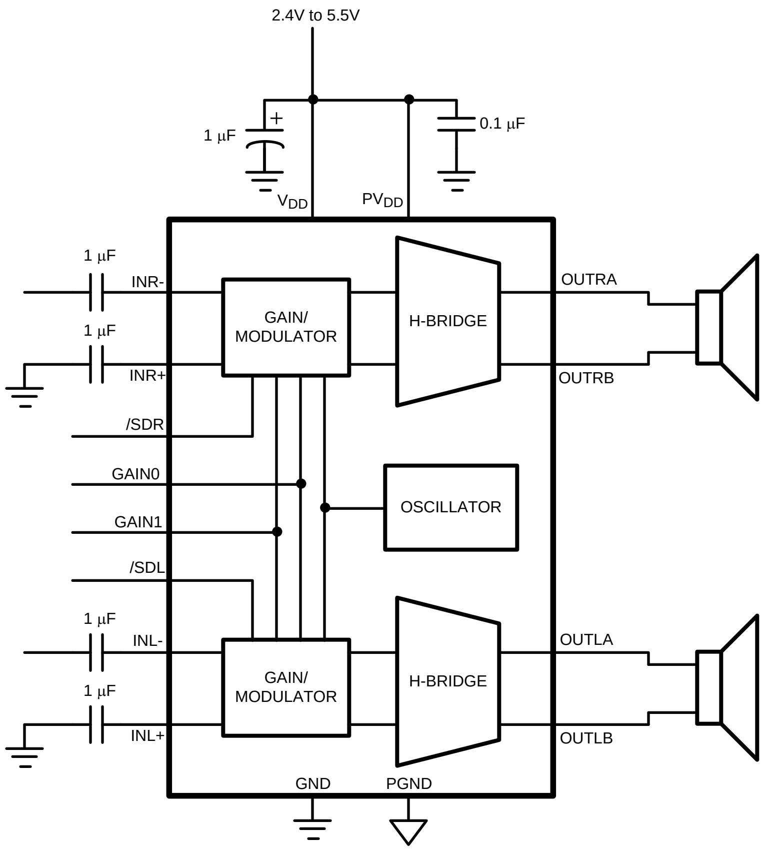
Symbol	Parameter	Conditions	LM4674A		Units (Limits)
			Typical[3]	Limit[4]	
PSRR	Power Supply Rejection Ratio	V_{RIPPLE} = 200mV_{P-P} Sine, f_{Ripple} = 217Hz, Inputs AC GND, C_I = 1µF, input referred	75		dB
		V_{RIPPLE} = 1V_{P-P} Sine, f_{Ripple} = 1kHz, Inputs AC GND, C_I = 1µF, input referred	75		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		%
	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

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.

Block Diagrams



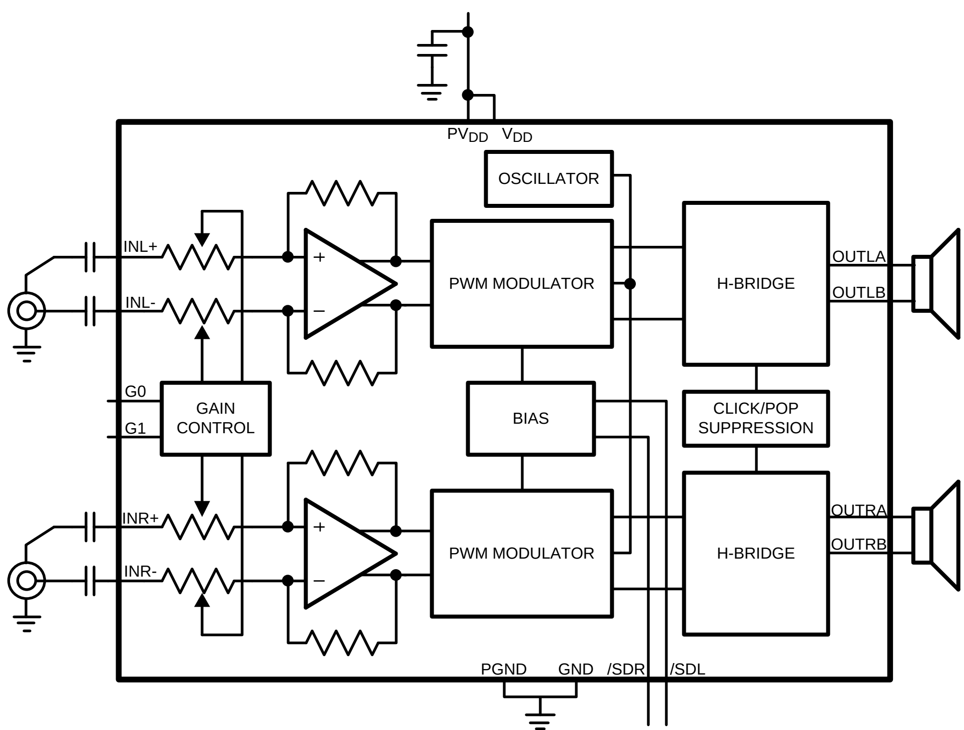


Figure 3. Differential Input Configuration

Typical Performance Characteristics

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

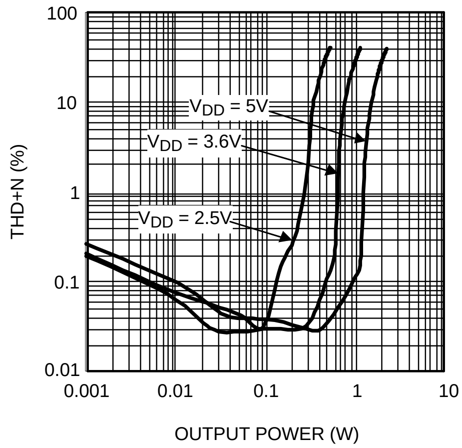


Figure 4.

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

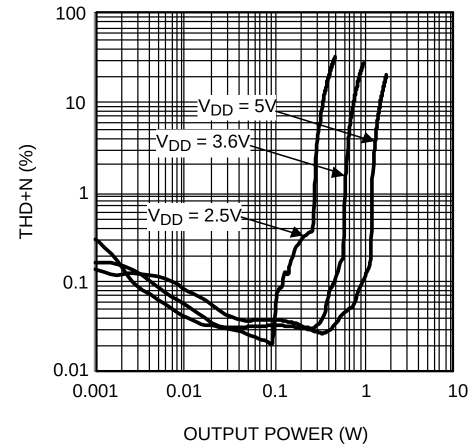


Figure 5.

THD+N vs Output Power
f= 1kHz, A_V = 24dB, R_L = 4Ω

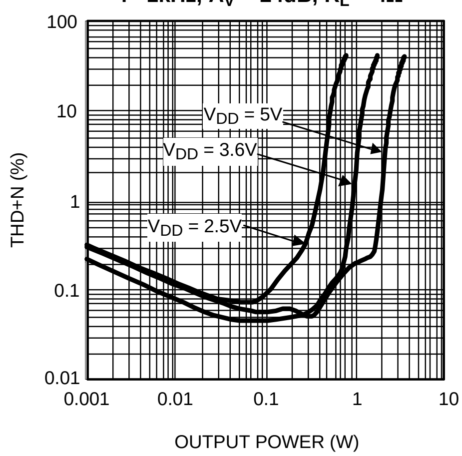


Figure 6.

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

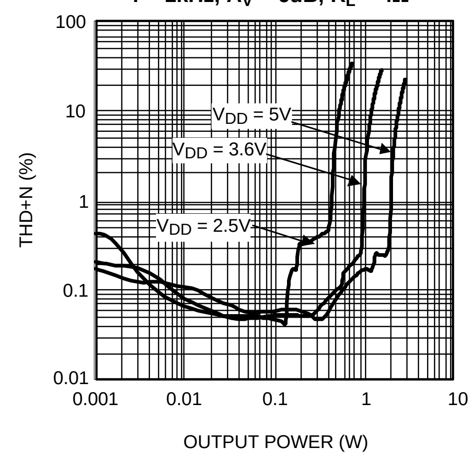


Figure 7.

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

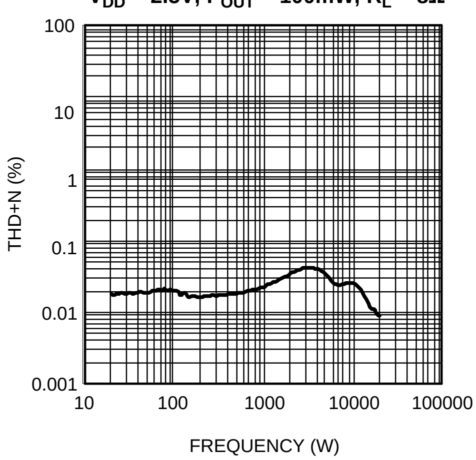


Figure 8.

THD+N vs Frequency
V_{DD} = 3.6V, P_{OUT} = 250mW, R_L = 8Ω

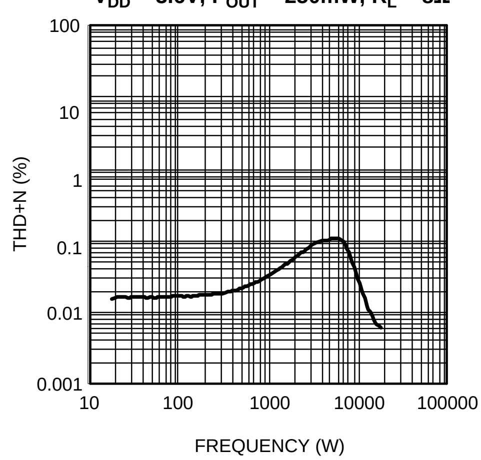


Figure 9.

Typical Performance Characteristics (continued)

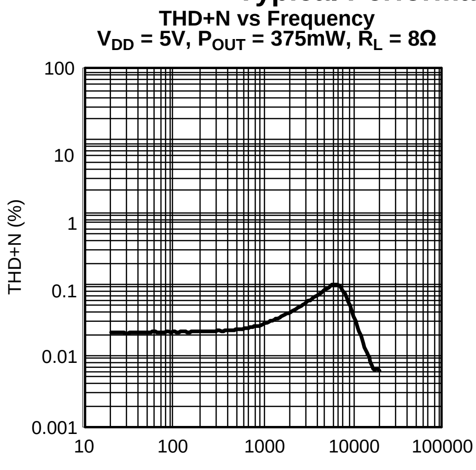


Figure 10.

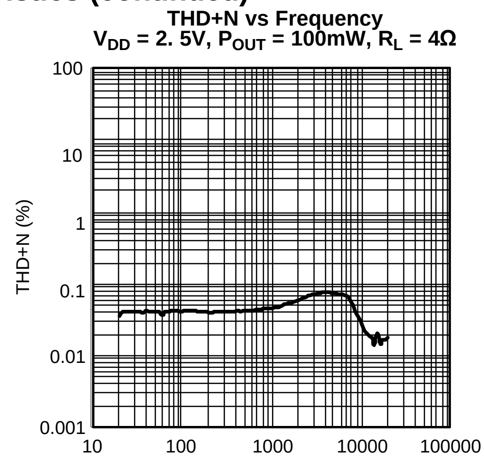


Figure 11.

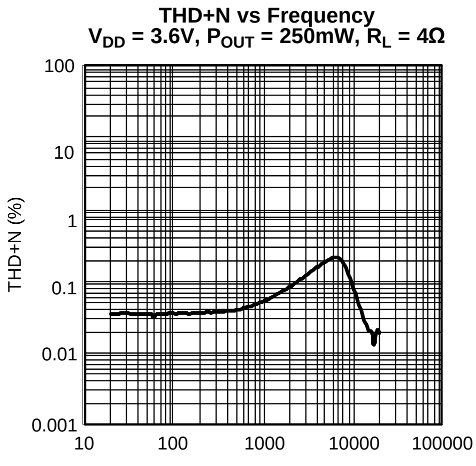


Figure 12.

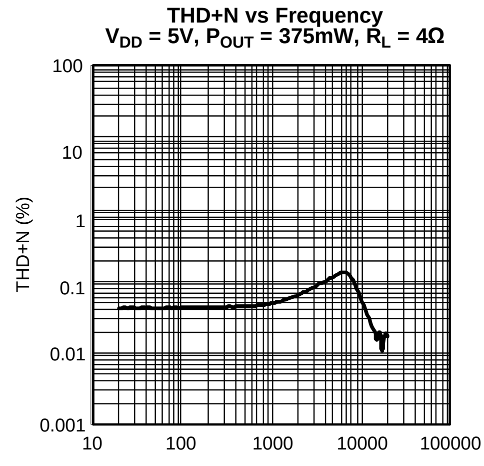


Figure 13.

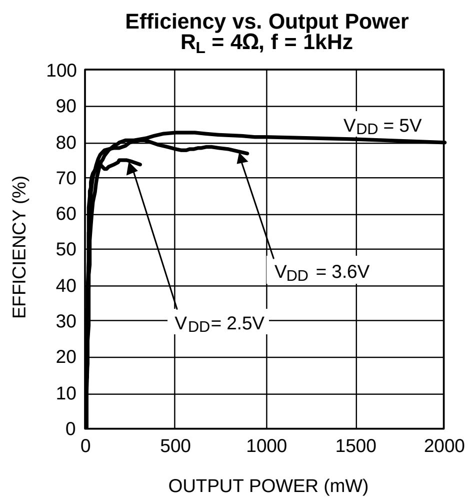


Figure 14.

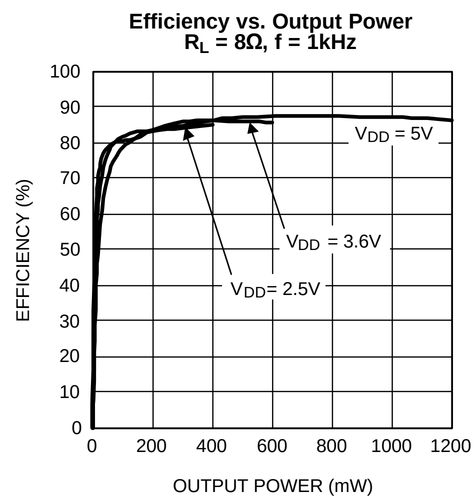


Figure 15.

Typical Performance Characteristics (continued)

Power Dissipation vs. Output Power
$R_L = 4\Omega$, f = 1kHz

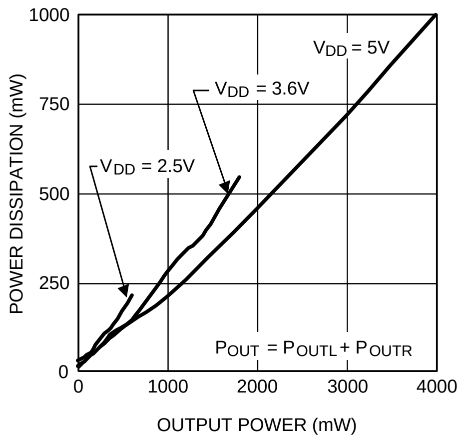


Figure 16.

Power Dissipation vs. Output Power
$R_L = 8\Omega$, f = 1kHz

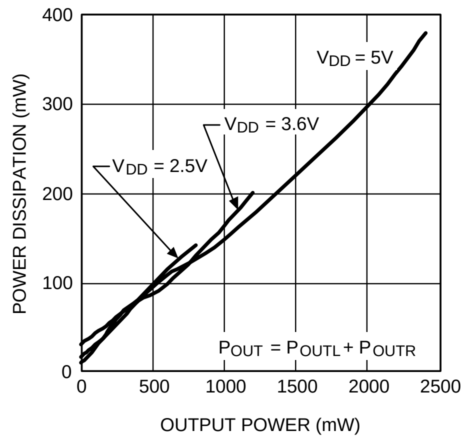


Figure 17.

Output Power vs. Supply Voltage
$R_L = 4\Omega$, f = 1kHz

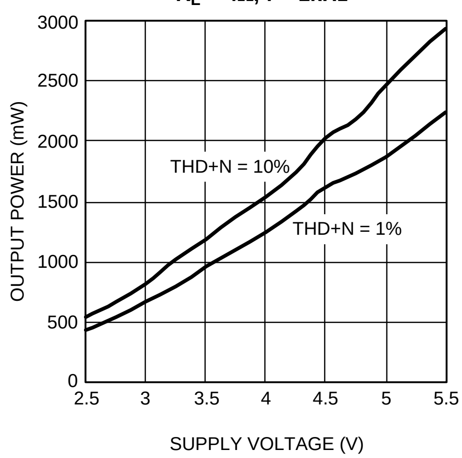


Figure 18.

Output Power vs. Supply Voltage
$R_L = 8\Omega$, f = 1kHz

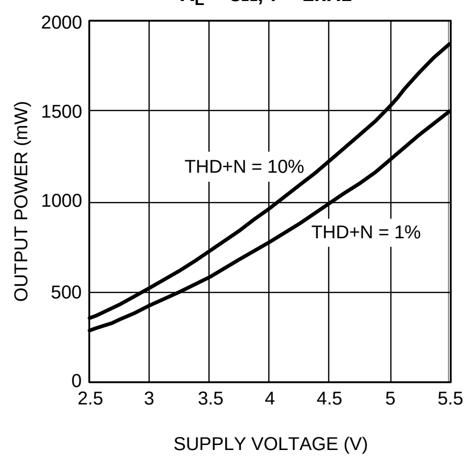


Figure 19.

PSRR vs. Frequency
V_{DD} = 3.6V, V_{RIPPLE}= 200mV$_{P-P}$, $R_L = 8\Omega$

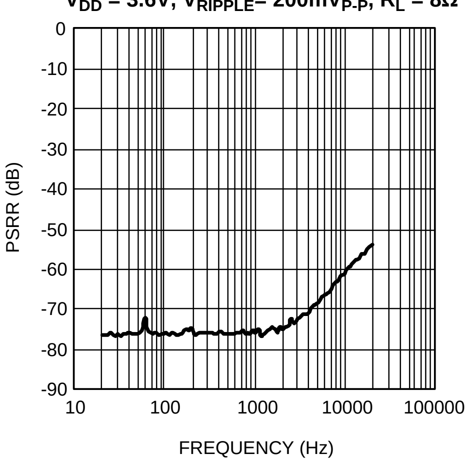


Figure 20.

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

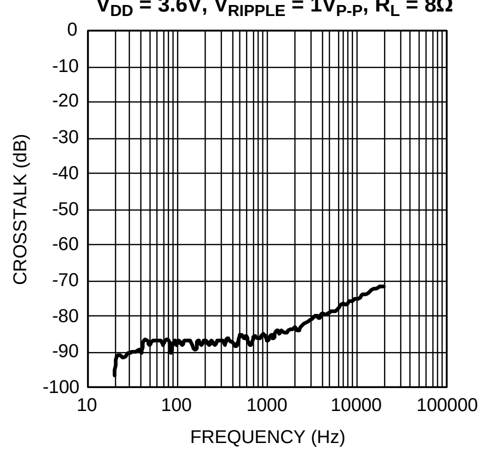


Figure 21.

Typical Performance Characteristics (continued)

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

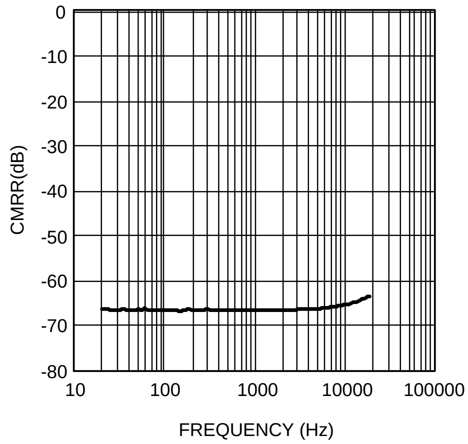


Figure 22.

Supply Current vs. Supply Voltage
No Load

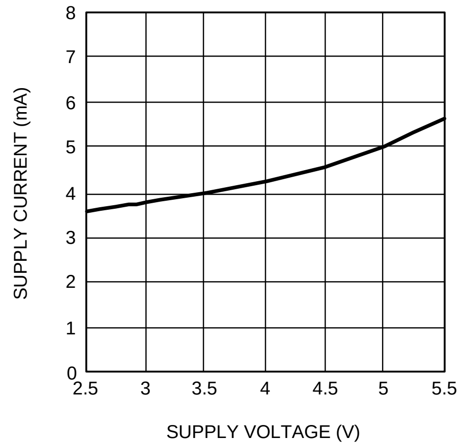


Figure 23.

APPLICATION INFORMATION

GENERAL AMPLIFIER FUNCTION

The LM4674A 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 (OUT_A and OUT_B) 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 LM4674A outputs changes. For increasing output voltage, the duty cycle of OUT_A increases, while the duty cycle of OUT_B decreases. For decreasing output voltages, the converse occurs. The difference between the two pulse widths yields the differential output voltage.

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 LM4674A 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 LM4674A 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.

POWER DISSIPATION AND EFFICIENCY

The major benefit of a Class D amplifier is increased efficiency versus a Class AB. The efficiency of the LM4674A 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, along with switching losses due to gate charge.

SHUTDOWN FUNCTION

The LM4674A features independent left and right channel shutdown controls, allowing each channel to be disabled independently. /SDR controls the right channel, while /SDL controls the left channel. Driving either low disables the corresponding channel, reducing supply current to 0.03µA.

It is best to switch between ground and V_{DD} for minimum current consumption while in shutdown. The LM4674A may be disabled with shutdown voltages in between GND and V_{DD}, the idle current will be greater than the typical 0.03µA value. Increased THD+N may also be observed when a voltage of less than V_{DD} is applied to /SD_ for logic levels between GND and V_{DD} Bypass /SD_ with a 0.1µF capacitor.

The LM4674A shutdown inputs have internal pulldown resistors. The purpose of these resistors is to eliminate any unwanted state changes when /SD_ is floating. To minimize shutdown current, /SD_ should be driven to GND or left floating. If /SD_ is not driven to GND or floating, an increase in shutdown supply current will be noticed.

SINGLE-ENDED AUDIO AMPLIFIER CONFIGURATION

The LM4674A is compatible with single-ended sources. When configured for single-ended inputs, input capacitors must be used to block and DC component at the input of the device. Figure 25 shows the typical single-ended applications circuit.

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 LM4674A supply pins. A 1µF capacitor is recommended.

AUDIO AMPLIFIER INPUT CAPACITOR SELECTION

Input capacitors may be 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 LM4674A. The input capacitors create a high-pass filter with the input resistors RI. The -3dB point of the high pass filter is found using Equation 1 below.

$$f = 1 / 2\pi R_{IN}C_{IN} \quad (1)$$

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 may even be damaged by low frequencies. High pass filtering the audio signal helps protect the speakers. When the LM4674A 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, 217Hz 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.

AUDIO AMPLIFIER GAIN SETTING

The LM4674A 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.

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

PCB 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 LM4674A and the load results in lower output power and decreased efficiency. Higher trace resistance between the supply and the LM4674A 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 of 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 LM4674A 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 LM4674A outputs may be needed to reduce EMI radiation.

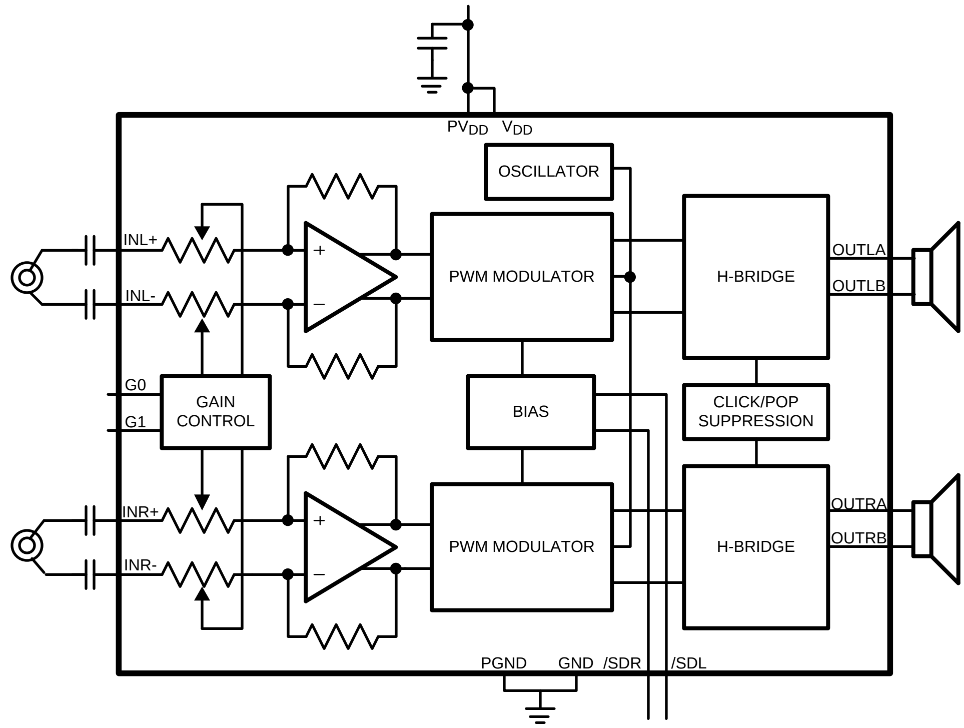


Figure 24. Differential Input Configuration

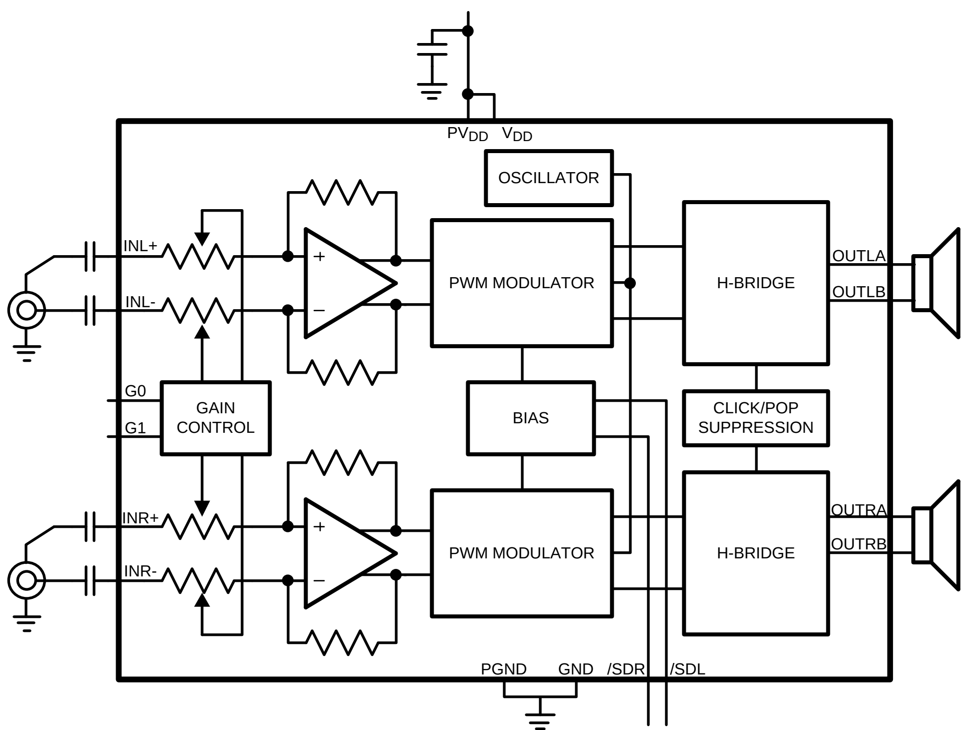


Figure 25. Single-Ended Input Configuration

REVISION HISTORY

Rev	Date	Description
1.0	9/13/06	Initial WEB release.

Changes from Original (May 2013) to Revision A **Page**

- Changed layout of National Data Sheet to TI format 13

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)
LM4674ATL/NOPB	Active	Production	DSBGA (YZR) | 16	250 | SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	GI2
LM4674ATL/NOPB.A	Active	Production	DSBGA (YZR) | 16	250 | SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	GI2
LM4674ATLX/NOPB	Active	Production	DSBGA (YZR) | 16	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	GI2
LM4674ATLX/NOPB.A	Active	Production	DSBGA (YZR) | 16	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	GI2

(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.

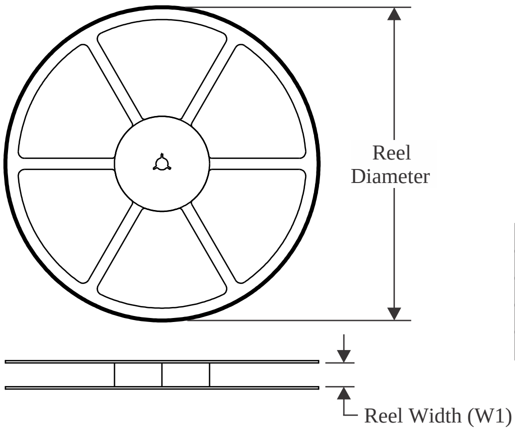
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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.

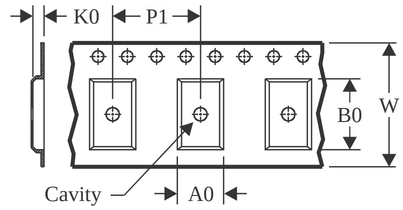
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

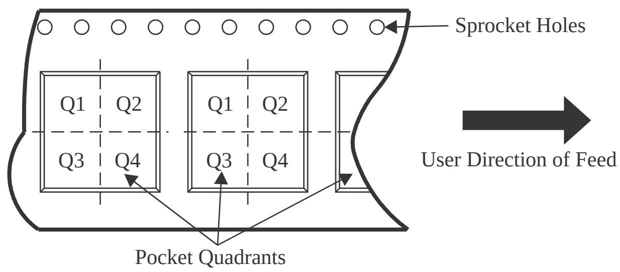


TAPE DIMENSIONS



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

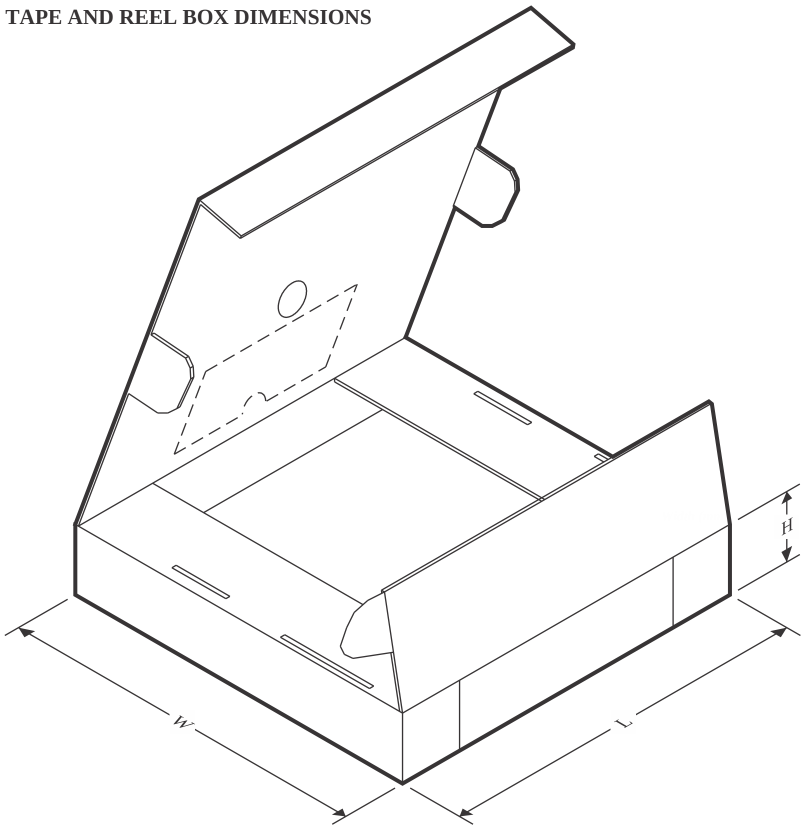
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

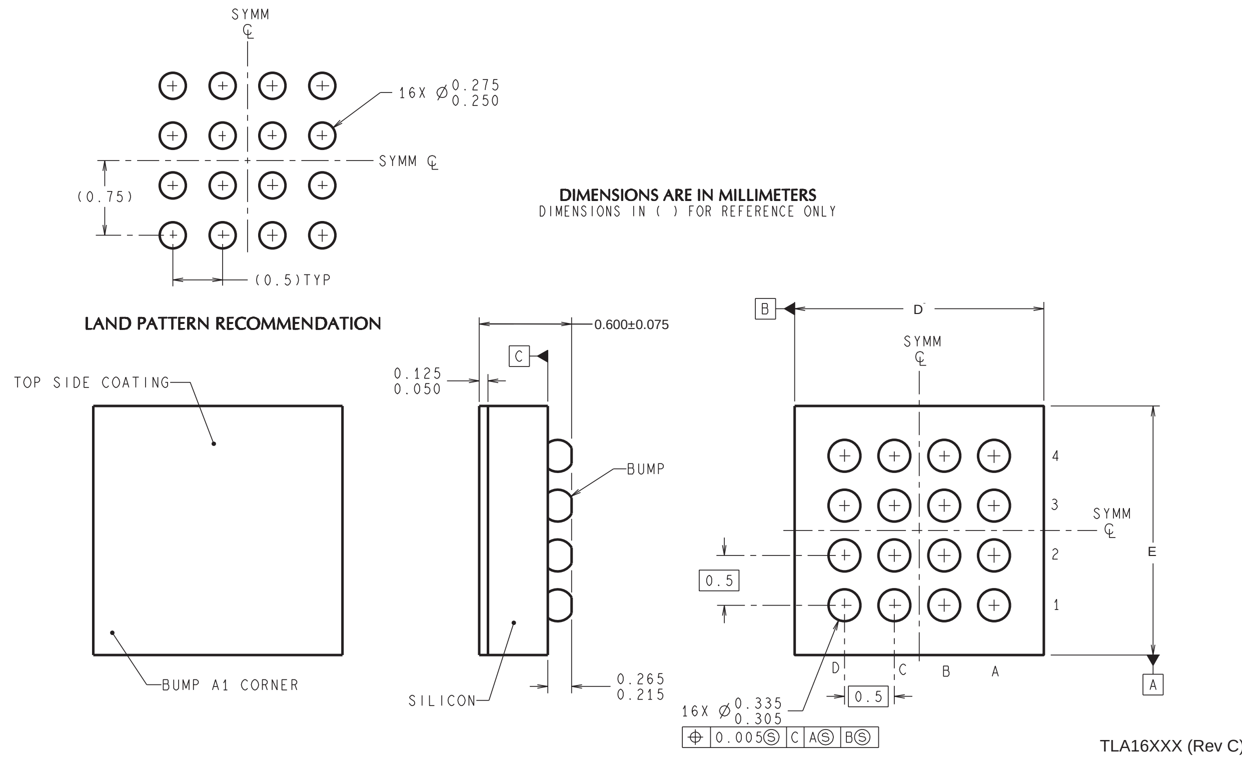
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM4674ATL/NOPB	DSBGA	YZR	16	250	178.0	8.4	2.08	2.08	0.76	4.0	8.0	Q1
LM4674ATLX/NOPB	DSBGA	YZR	16	3000	178.0	8.4	2.08	2.08	0.76	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM4674ATL/NOPB	DSBGA	YZR	16	250	208.0	191.0	35.0
LM4674ATLX/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	

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

IMPORTANT NOTICE AND DISCLAIMER