LM4902 Boomer™ Audio Power Amplifier Series 265mW at 3.3V Supply Audio Power Amplifier with Shutdown Mode

Check for Samples: LM4902

FEATURES

- **VSSOP and WSON Packaging**
- **No Output Coupling Capacitors, Bootstrap Capacitors, or Snubber Circuits are Necessary**
- **Thermal Shutdown Protection Circuitry**
- **Unity-Gain Stable**
- **External Gain Configuration Capability**
- **Latest Generation "Click and Pop" Suppression Circuitry**

APPLICATIONS

- **Cellular Phones**
- **PDA's**
- **Any Portable Audio Application**

KEY SPECIFICATIONS

- **THD+N at 1kHz for 265mW Continuous Average Output Power into 8Ω, V_{DD} = 3.3V 1.0% (max)**
- **THD+N at 1kHz for 675mW Continuous Average Output Power into 8Ω, V_{DD} = 5V 1.0% (max)**
- **Shutdown Current 0.1µA (typ)**

DESCRIPTION

The LM4902 is a bridged audio power amplifier capable of delivering 265mW of continuous average power into an 8Ω load with 1% THD+N from a 3.3V power supply.

Boomer™ audio power amplifiers were designed specifically to provide high quality output power from a low supply voltage while requiring a minimal amount of external components. Since the LM4902 does not require output coupling capacitors, bootstrap capacitors or snubber networks, it is optimally suited for low-power portable applications.

The LM4902 features an externally controlled, low power consumption shutdown mode, and thermal shutdown protection.

The closed loop response of the unity-gain stable LM4902 can be configured by external gain-setting resistors.

Typical Application

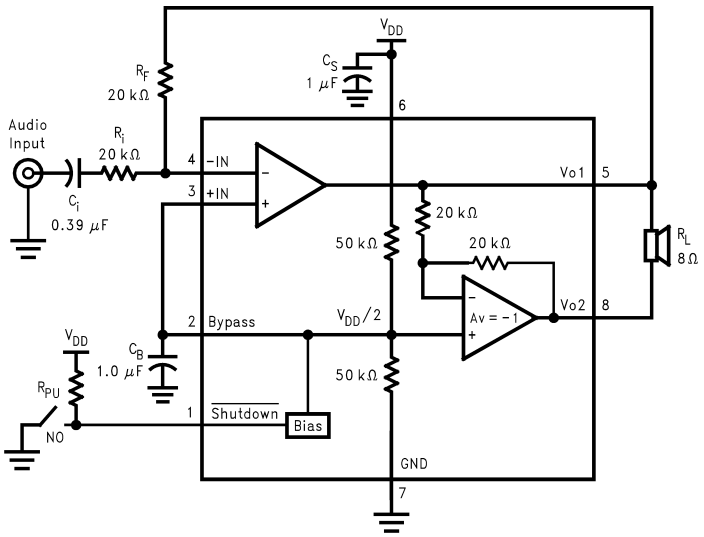


Figure 1. Typical Audio Amplifier Application Circuit

Connection Diagrams

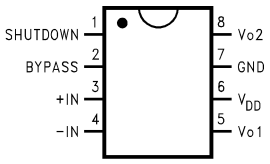


Figure 2. VSSOP - Top View
See Package Number DGK

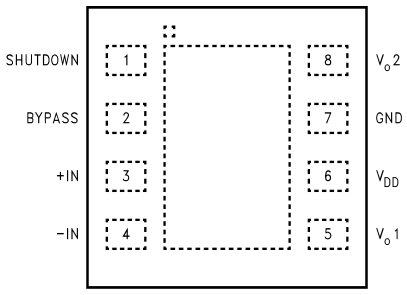


Figure 3. WSON - Top View
See Package Number NGL

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings[1][2]

Supply Voltage			6.0V
Storage Temperature			−65°C to +150°C
Input Voltage			−0.3V to V_{DD} + 0.3V
Power Dissipation[3]			Internally limited
ESD Susceptibility[4]			2000V
ESD Susceptibility[5]			200V
Junction Temperature			150°C
Soldering Information	Small Outline Package	Vapor Phase (60 sec.)	215°C
		Infrared (15 sec.)	220°C
Thermal Resistance		θ_{JC} (VSSOP)	56°C/W
		θ_{JA} (VSSOP)	190°C/W
		θ_{JA} (WSON)	67°C/W

(1) 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.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.
(3) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{JMAX}, 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 the Absolute Maximum Ratings, whichever is lower. For the LM4902, T_{JMAX} = 150°C. The typical junction-to-ambient thermal resistance, when board mounted, is 190°C/W for package number DGK.
(4) Human body model, 100pF discharged through a 1.5kΩ resistor.
(5) Machine Model, 220pF–240pF discharged through all pins.

Operating Ratings

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

Electrical Characteristics[1][2]

The following specifications apply for V_{DD} = 5V, for all available packages, unless otherwise specified. Limits apply for T_A = 25°C.

Symbol	Parameter	Conditions	LM4902		Units (Limits)
			Typical[3]	Limit[4][5]	
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0V, I_O = 0A[6]	4	6.0	mA (max)
I_{SD}	Shutdown Current	V_{PIN1} =GND	0.1	5	µA (max)
V_{OS}	Output Offset Voltage	V_{IN} = 0V	5	50	mV (max)
P_O	Output Power	THD = 1% (max); f = 1kHz; R_L = 8Ω;	675	300	mW (min)
THD+N	Total Harmonic Distortion+Noise	P_O = 400 mWrms; A_{VD} = 2; R_L = 8Ω; 20Hz ≤ f ≤ 20kHz, BW < 80kHz	0.4		%

(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).
(5) Datasheet min/max specification limits are specified by design, test, or statistical analysis.
(6) The quiescent power supply current depends on the offset voltage when a practical load is connected to the amplifier.

Electrical Characteristics[1][2] (continued)

The following specifications apply for V_{DD} = 5V, for all available packages, unless otherwise specified. Limits apply for T_A = 25°C.

Symbol	Parameter	Conditions	LM4902		Units (Limits)
			Typical[3]	Limit[4][5]	
PSRR	Power Supply Rejection Ratio	V_{RIPPLE} = 200mV sine p-p			dB
		f = 217Hz[7]	70		
		f = 1KHz[7]	67		
		f = 217Hz[8]	55		
		f = 1KHz[8]	55		

(7) Unterminated input.
(8) 10Ω terminated input.

Electrical Characteristics (1)(2)

The following specifications apply for V_{DD} = 3.3V, for all available packages, unless otherwise specified. Limits apply for T_A = 25°C.

Symbol	Parameter	Conditions	LM4902		Units (Limits)
			Typical (3)	Limit (4)(5)	
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0V, I_O = 0A (6)	3	5	mA (max)
I_{SD}	Shutdown Current	V_{PIN1} = GND	0.1	3	µA (max)
V_{OS}	Output Offset Voltage	V_{IN} = 0V	5	50	mV (max)
P_O	Output Power	THD = 1% (max); f = 1kHz; R_L = 8Ω;	265		mW
THD+N	Total Harmonic Distortion+Noise	P_O = 250 mWrms; A_{VD} = 2; R_L = 8Ω; 20Hz ≤ f ≤ 20kHz, BW < 80kHz	0.4		%
PSRR	Power Supply Rejection Ratio	V_{RIPPLE} = 200mV sine p-p			dB
		f = 217Hz (7)	73		
		f = 1KHz (7)	70		
		f = 217Hz (8)	60		
		f = 1KHz (8)	68		

(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).
(5) Datasheet min/max specification limits are specified by design, test, or statistical analysis.
(6) The quiescent power supply current depends on the offset voltage when a practical load is connected to the amplifier.
(7) Unterminated input.
(8) 10Ω terminated input.

Electrical Characteristics (1)(2)

The following specifications apply for V_{DD} = 2.6V, for all available packages, unless otherwise specified. Limits apply for T_A = 25°C.

Symbol	Parameter	Conditions	LM4902		Units (Limits)
			Typical (3)	Limit (4)(5)	
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0V, I_O = 0A (6)	2.6	4	mA (max)
I_{SD}	Shutdown Current	V_{PIN1} = V_{DD}	0.1	2.0	µA (max)
V_{OS}	Output Offset Voltage	V_{IN} = 0V	5		mV
P_O	Output Power	THD = 1% (max); f = 1kHz; R_L = 8Ω	130		mW
THD+N	Total Harmonic Distortion+Noise	P_O = 100 mWrms; A_{VD} = 2; R_L = 8Ω; 20Hz ≤ f ≤ 20kHz, BW < 80kHz	0.4		%
PSRR	Power Supply Rejection Ratio	V_{RIPPLE} = 200mV sine p-p			dB
		f = 217Hz (7)	58		
		f = 1KHz (7)	63		

(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).
(5) Datasheet min/max specification limits are specified by design, test, or statistical analysis.
(6) The quiescent power supply current depends on the offset voltage when a practical load is connected to the amplifier.
(7) 10Ω terminated input.

External Components Description

(Figure 1)

Components		Functional Description
1.	R_i	Inverting input resistance which sets the closed-loop gain in conjunction with R_F. This resistor also forms a high pass filter with C_i at $f_c = 1/(2\pi R_i C_I)$.
2.	C_i	Input coupling capacitor which blocks the DC voltage at the amplifier's input terminals. Also creates a highpass filter with R_i at $f_c = 1/(2\pi R_i C_i)$. Refer to the section, PROPER SELECTION OF EXTERNAL COMPONENTS, for an explanation of how to determine the value of C_i.
3.	R_F	Feedback resistance which sets the closed-loop gain in conjunction with R_i.
4.	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.
5.	C_B	Bypass pin capacitor which provides half-supply filtering. Refer to the PROPER SELECTION OF EXTERNAL COMPONENTS for information concerning proper placement and selection of C_B.

Typical Performance Characteristics

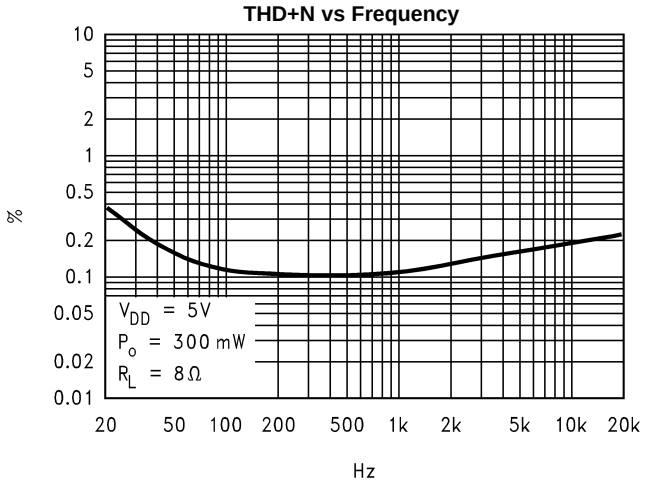


Figure 4.

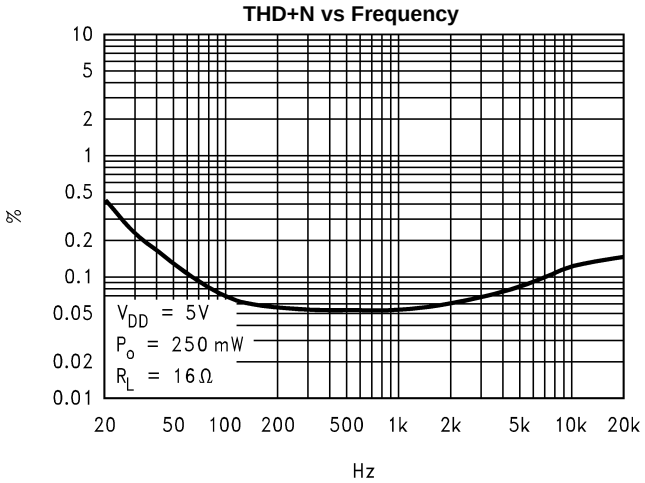
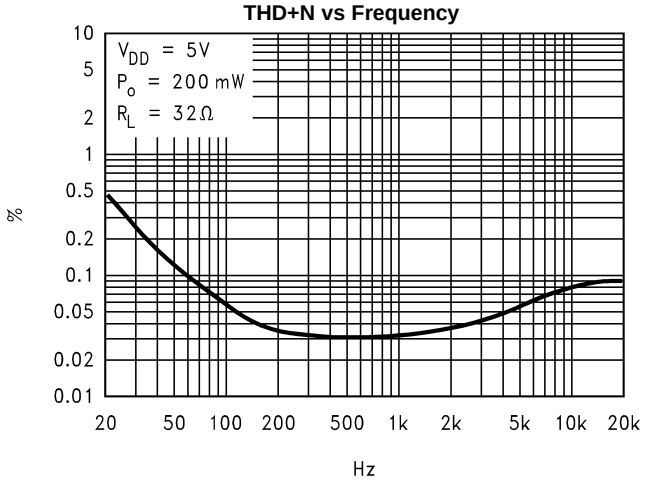


Figure 5.



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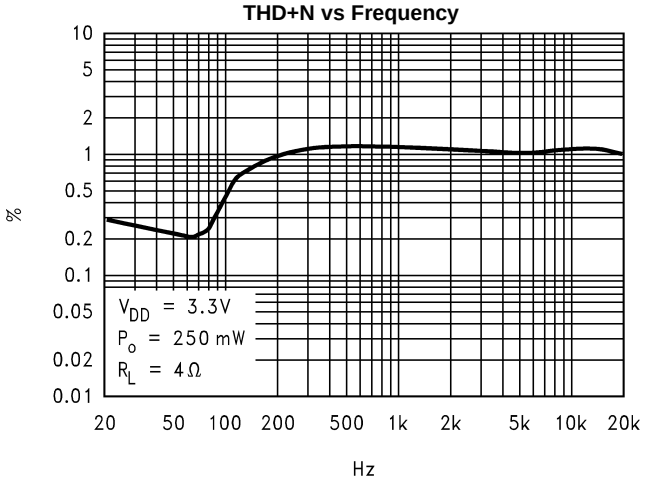

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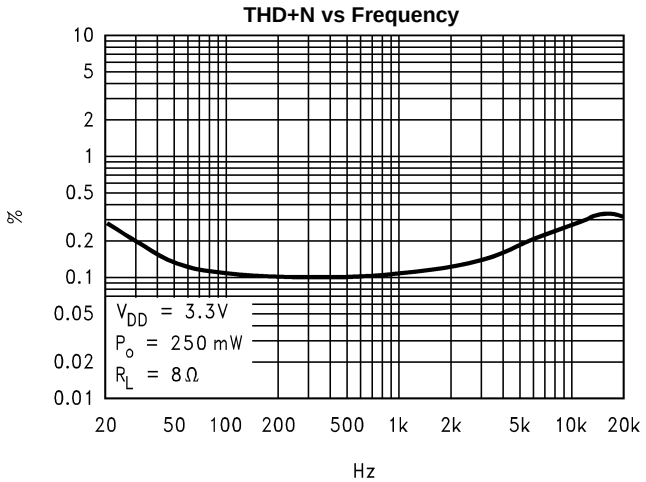


Figure 8.

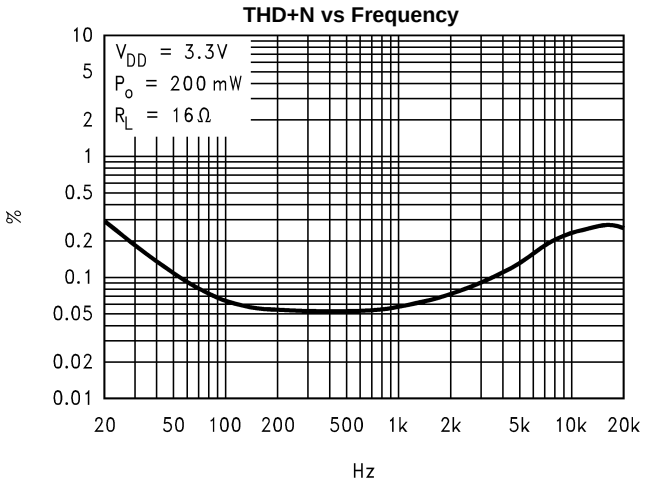


Figure 9.

Typical Performance Characteristics (continued)

THD+N vs Frequency

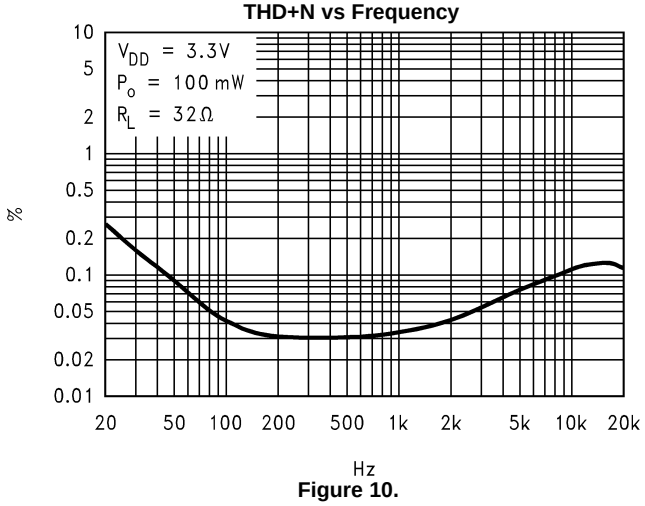


Figure 10.

THD+N vs Frequency

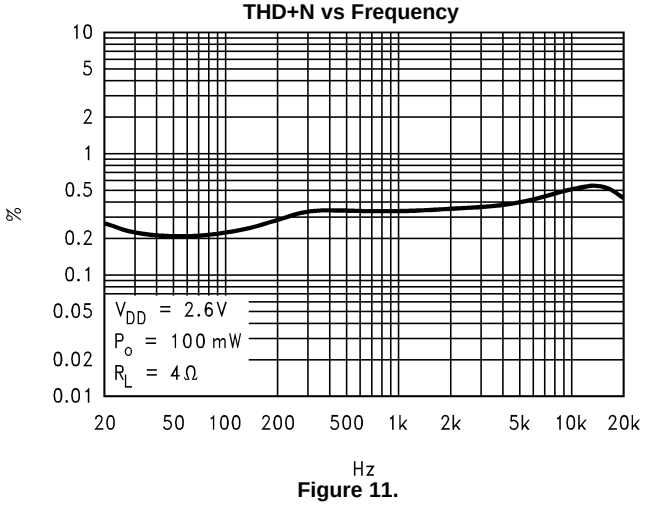


Figure 11.

THD+N vs Frequency

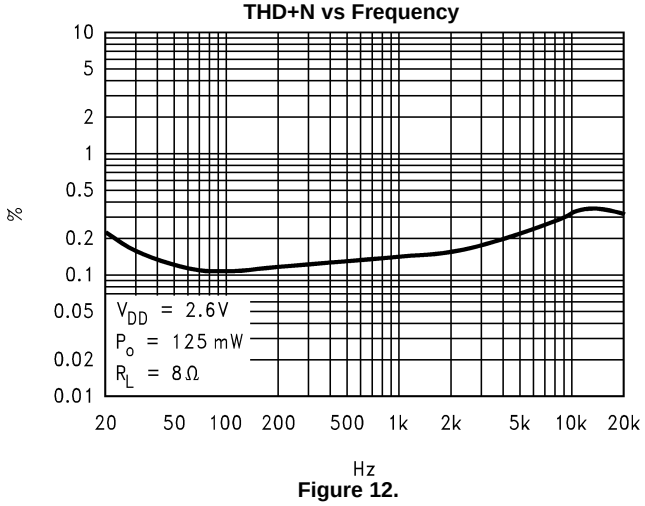


Figure 12.

THD+N vs Frequency

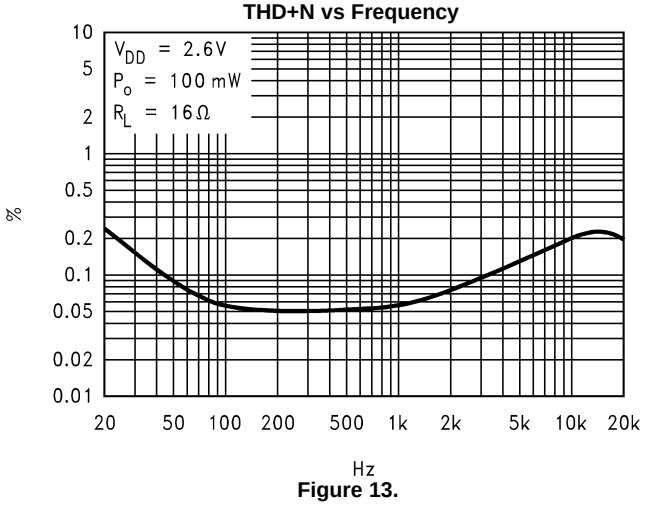


Figure 13.

THD+N vs Frequency

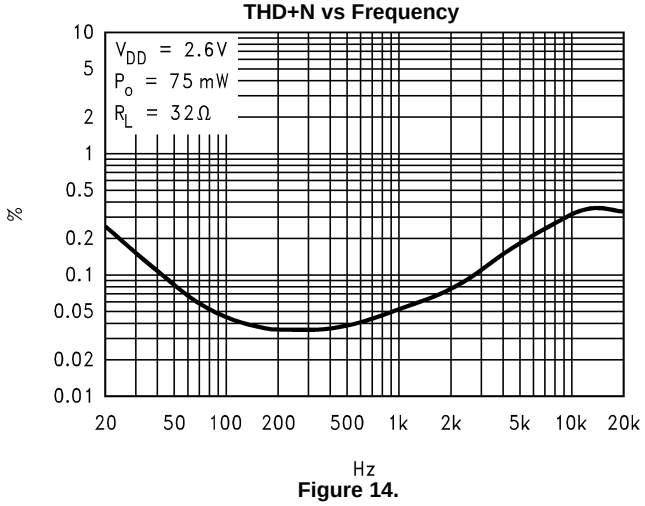


Figure 14.

THD+N vs Output Power

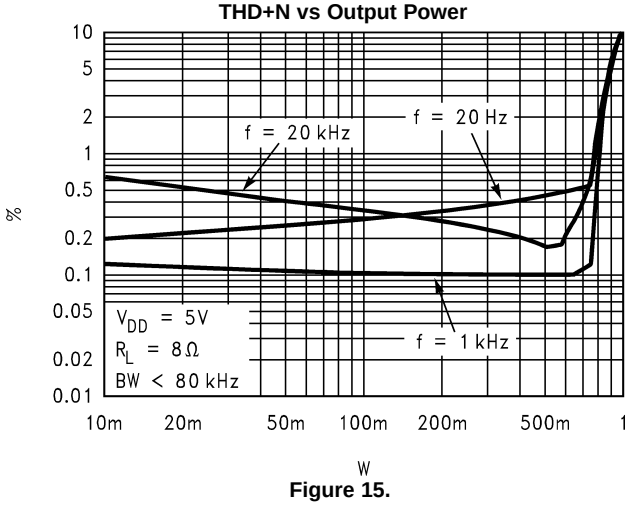


Figure 15.

Typical Performance Characteristics (continued)

THD+N vs Output Power

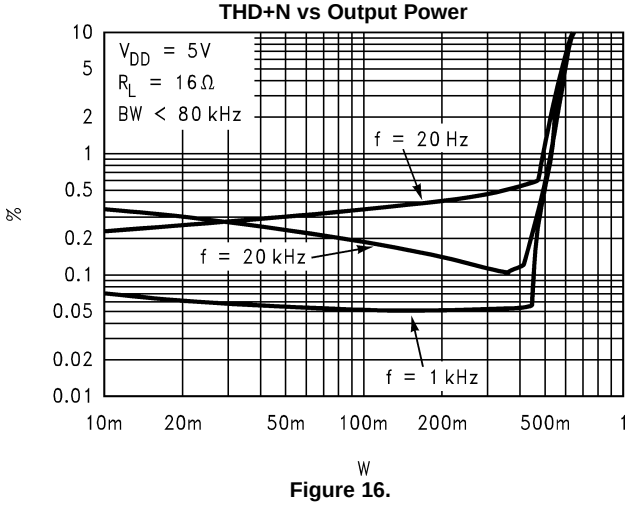


Figure 16.

THD+N vs Output Power

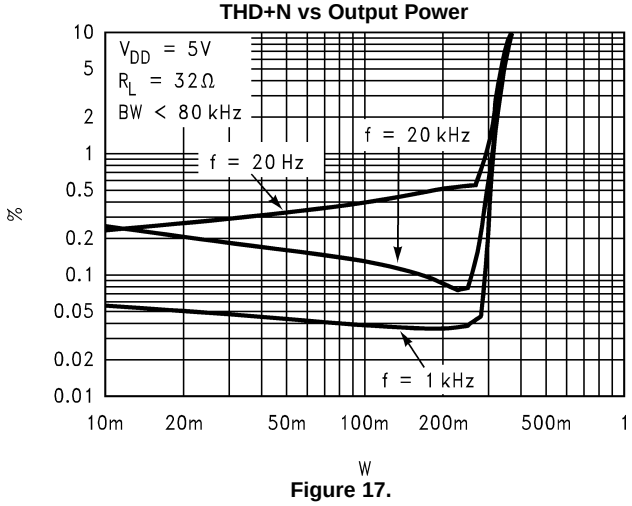


Figure 17.

THD+N vs Output Power

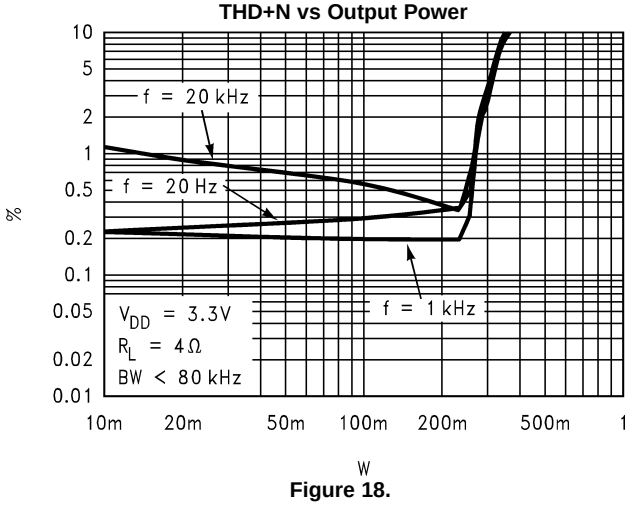


Figure 18.

THD+N vs Output Power

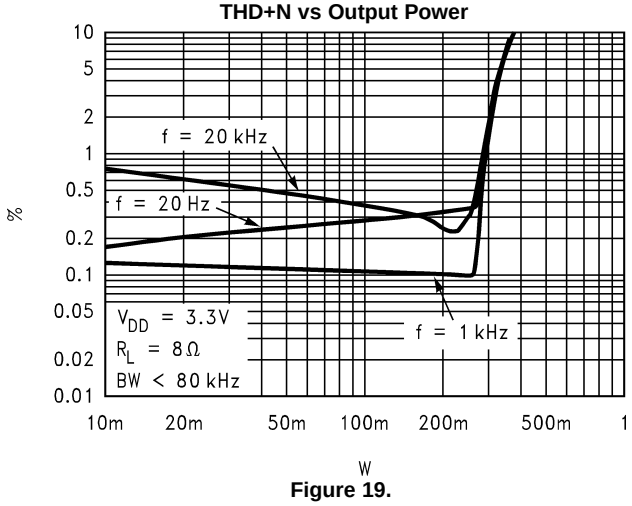


Figure 19.

THD+N vs Output Power

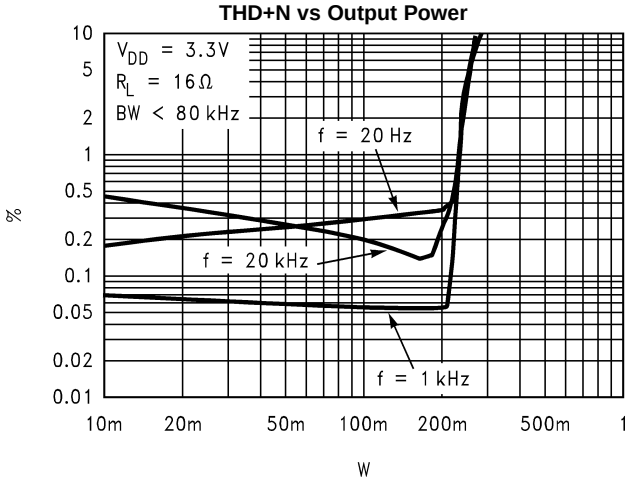


Figure 20.

THD+N vs Output Power

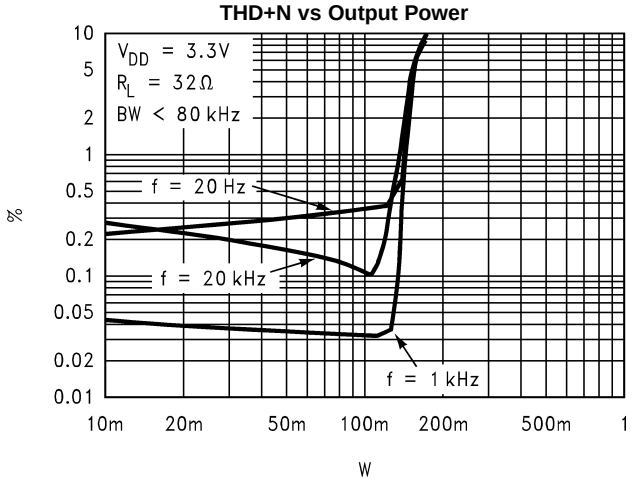


Figure 21.

Typical Performance Characteristics (continued)

THD+N vs Output Power

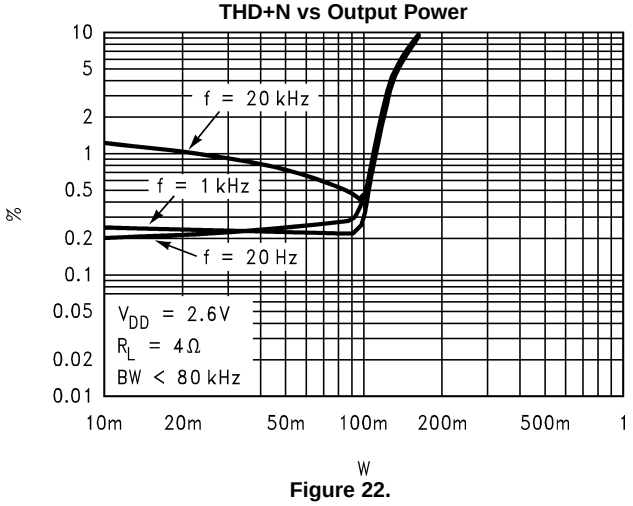


Figure 22.

THD+N vs Output Power

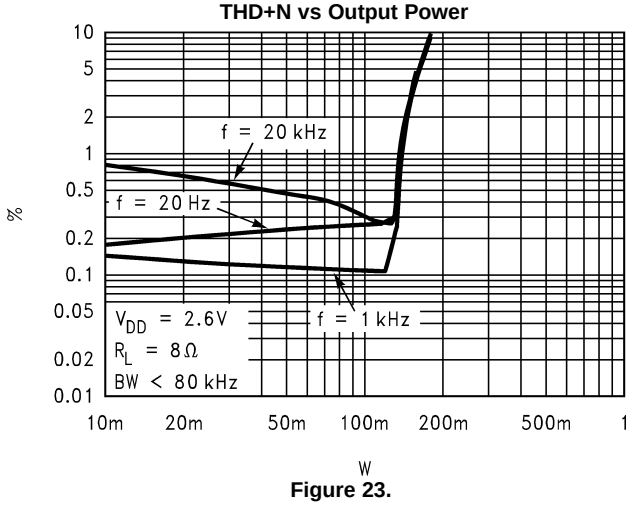


Figure 23.

THD+N vs Output Power

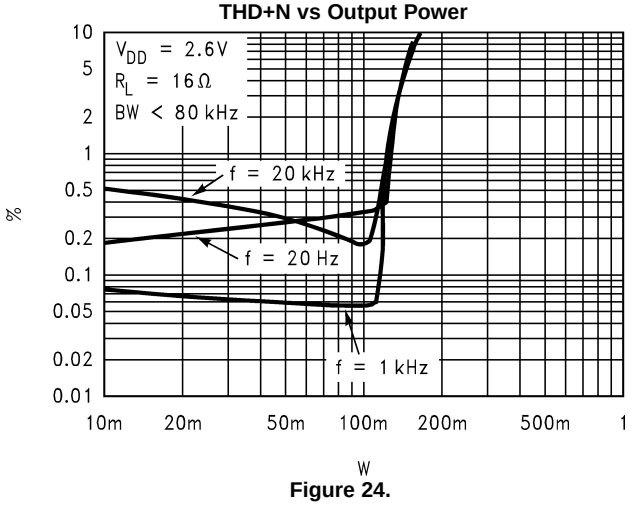


Figure 24.

THD+N vs Output Power

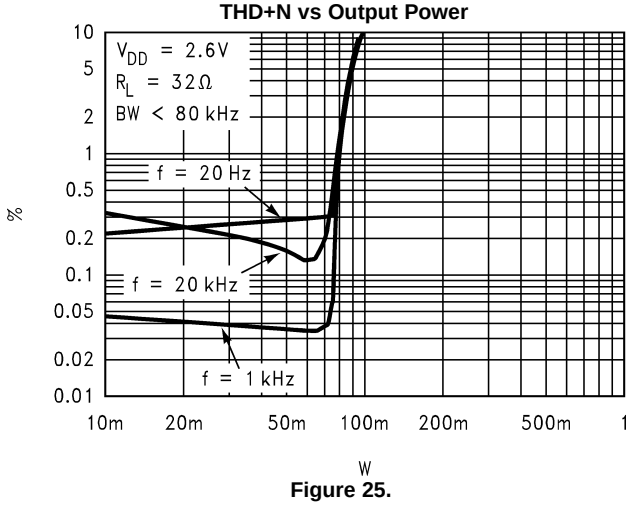


Figure 25.

Output Power vs Supply Voltage

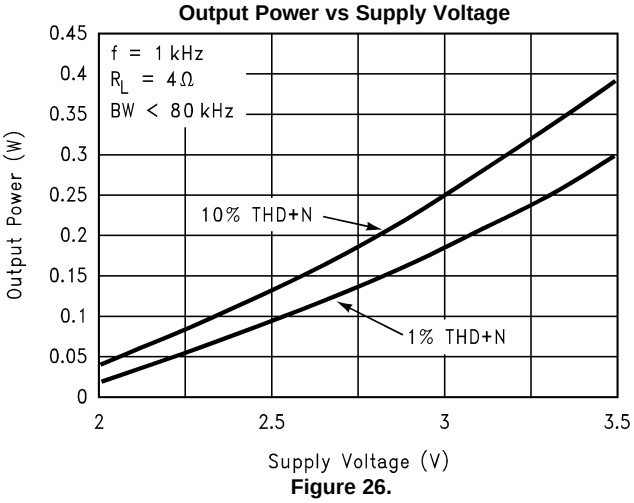


Figure 26.

Output Power vs Supply Voltage

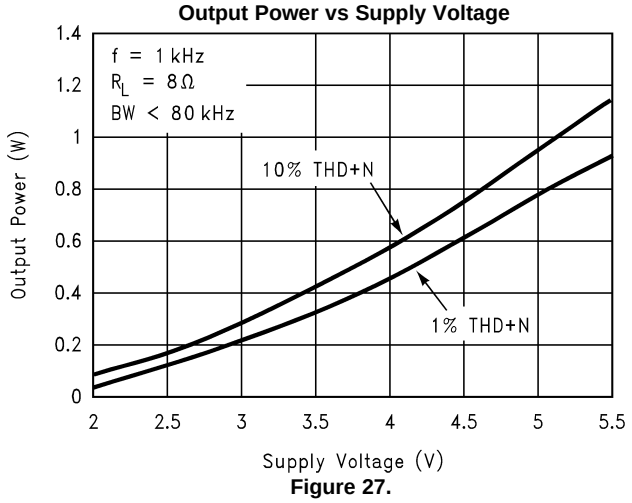


Figure 27.

Typical Performance Characteristics (continued)

Output Power vs Supply Voltage

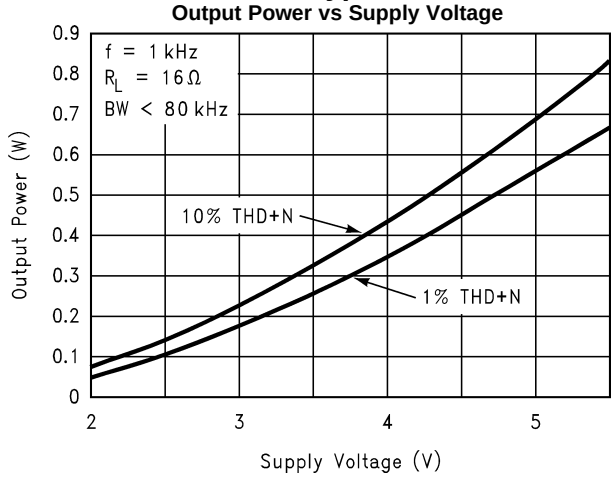


Figure 28.

Output Power vs Supply Voltage

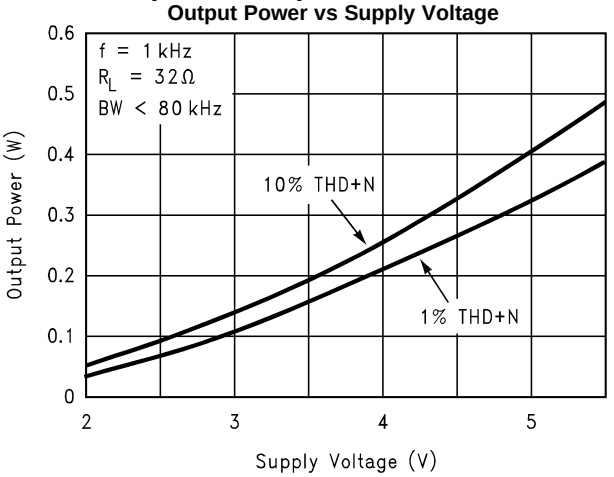


Figure 29.

Output Power vs Load Resistance

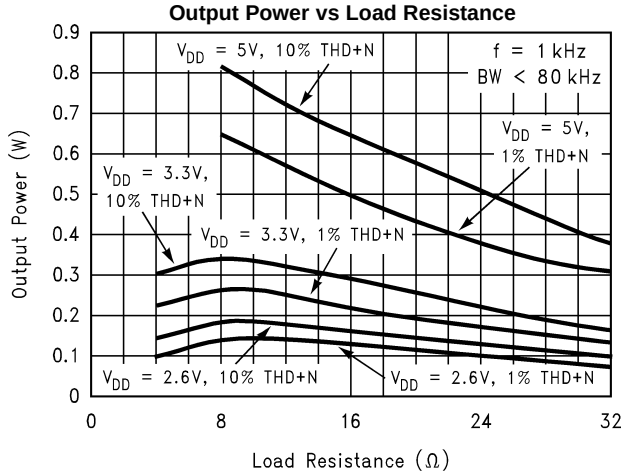


Figure 30.

Power Dissipation vs Output Power

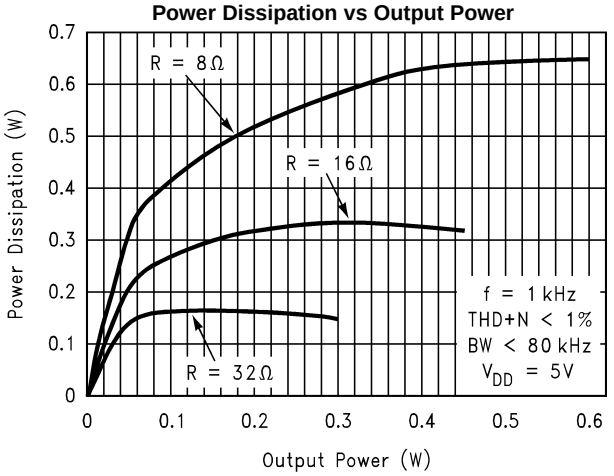


Figure 31.

Power Dissipation vs Output Power

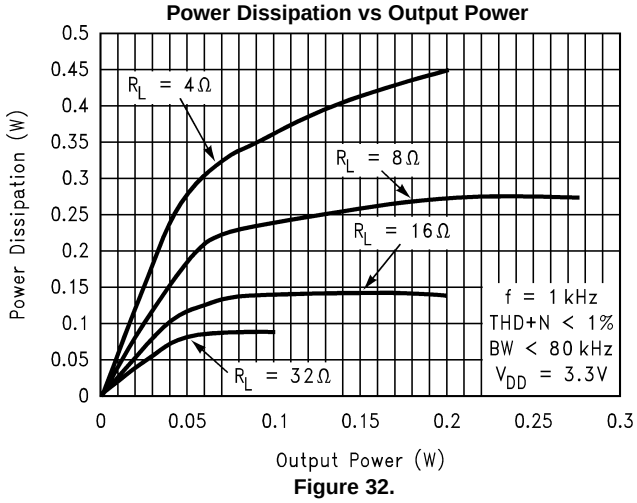


Figure 32.

Power Dissipation vs Output Power

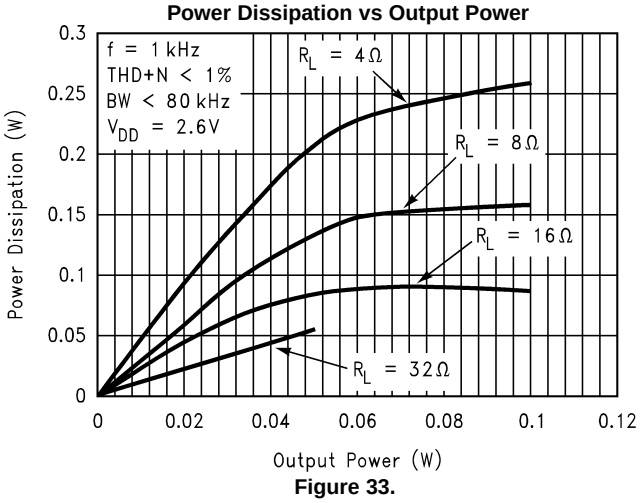


Figure 33.

Typical Performance Characteristics (continued)

Clipping Voltage vs Supply Voltage

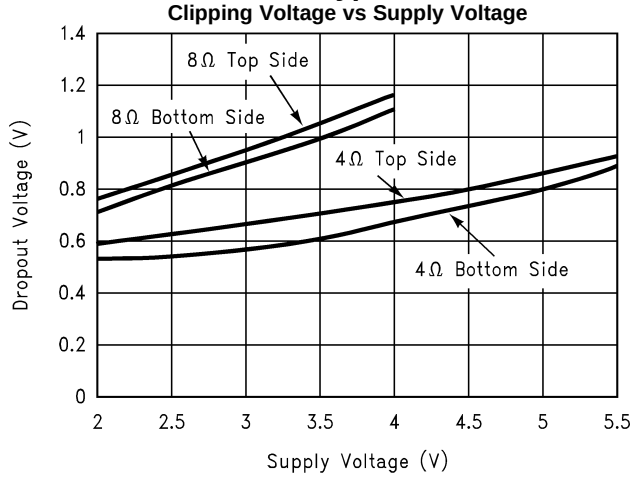


Figure 34.

Noise Floor

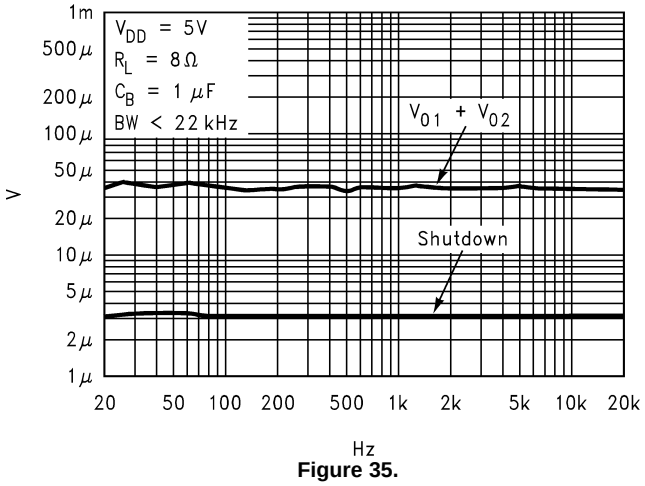


Figure 35.

Noise Floor

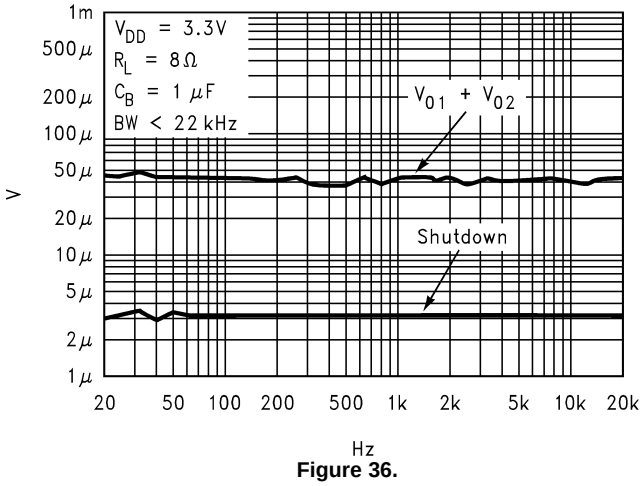


Figure 36.

Frequency Response vs Input Capacitor Size

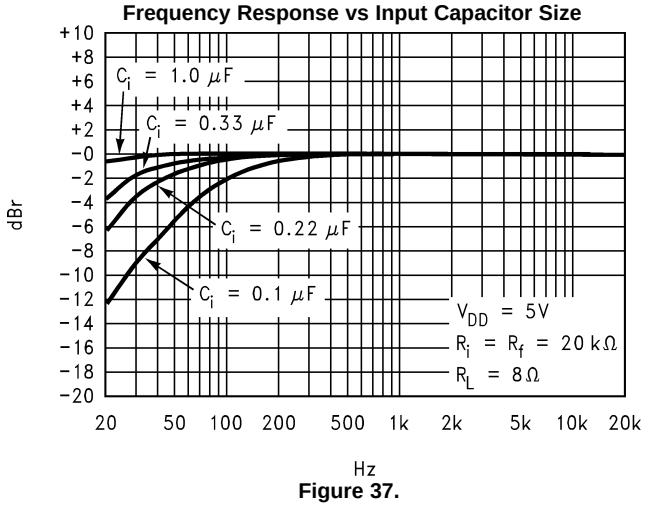


Figure 37.

Power Supply Rejection Ratio

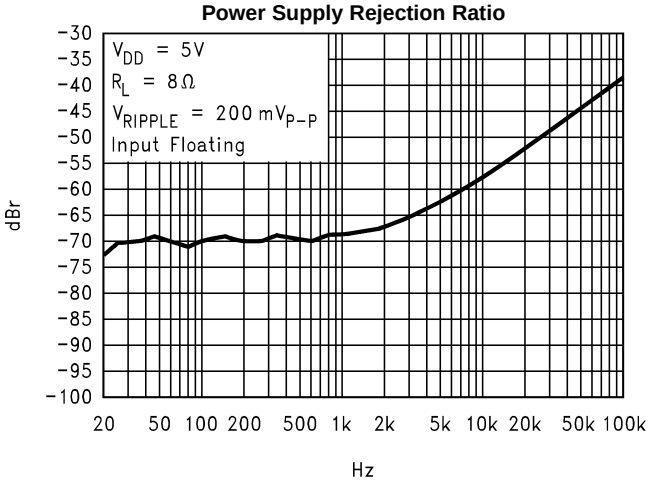


Figure 38.

Power Supply Rejection Ratio

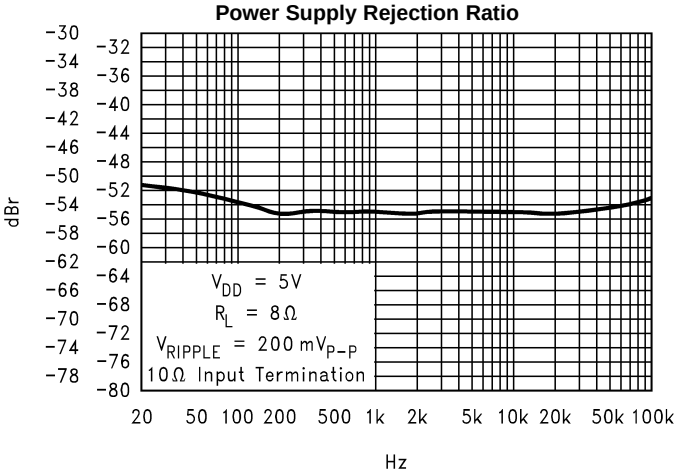


Figure 39.

Typical Performance Characteristics (continued)

Power Supply Rejection Ratio

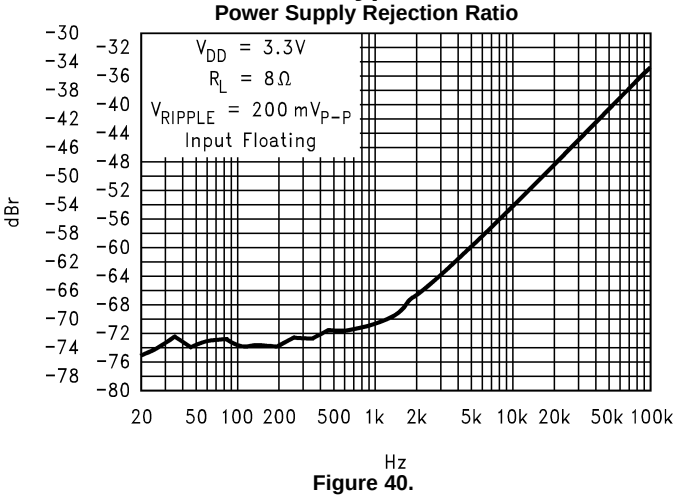


Figure 40.

Power Supply Rejection Ratio

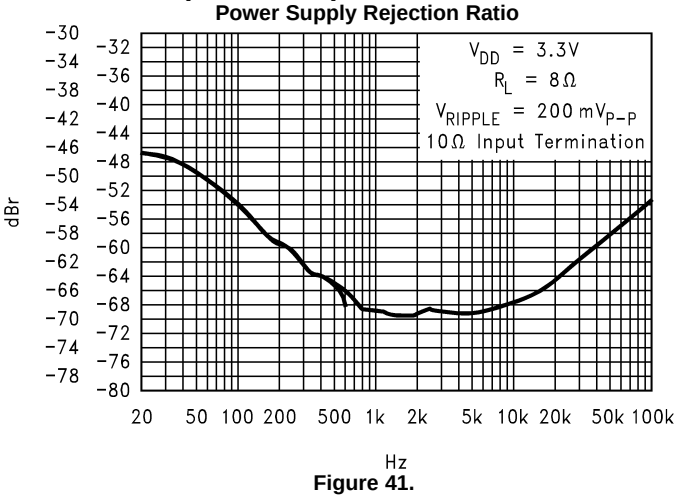


Figure 41.

Power Supply Rejection Ratio vs Supply Voltage

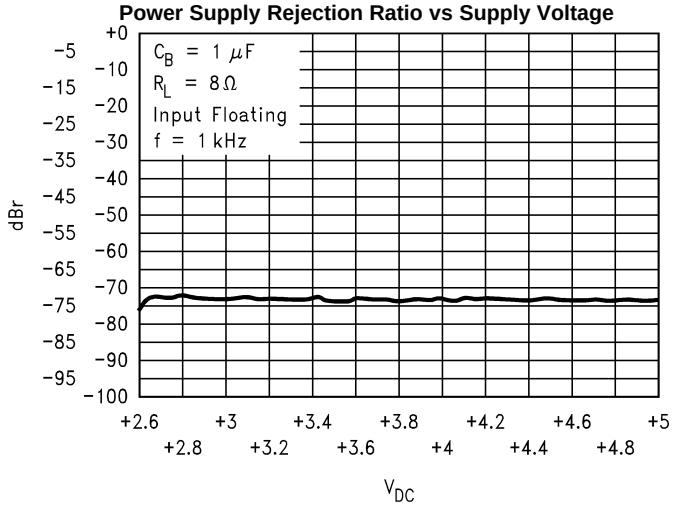


Figure 42.

Power Supply Rejection Ratio vs Supply Voltage

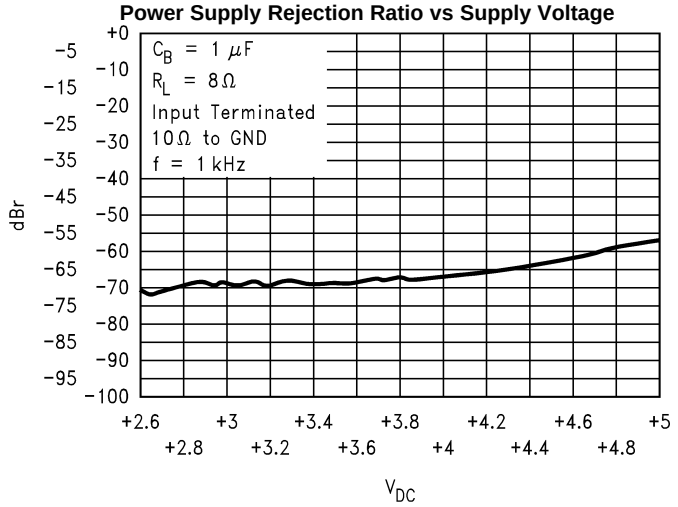


Figure 43.

Power Derating Curve

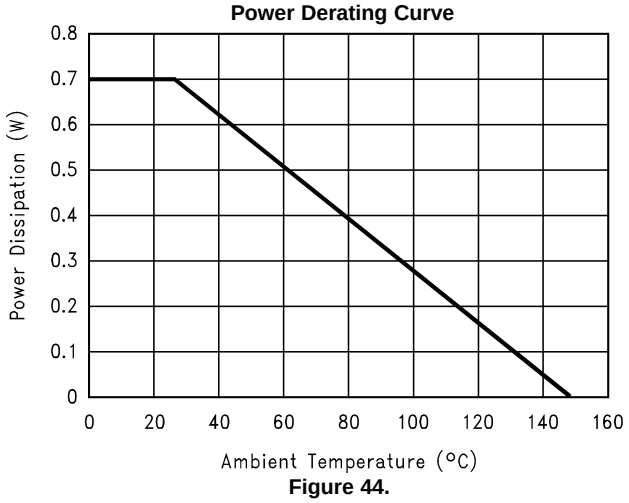


Figure 44.

Supply Current vs Supply Voltage

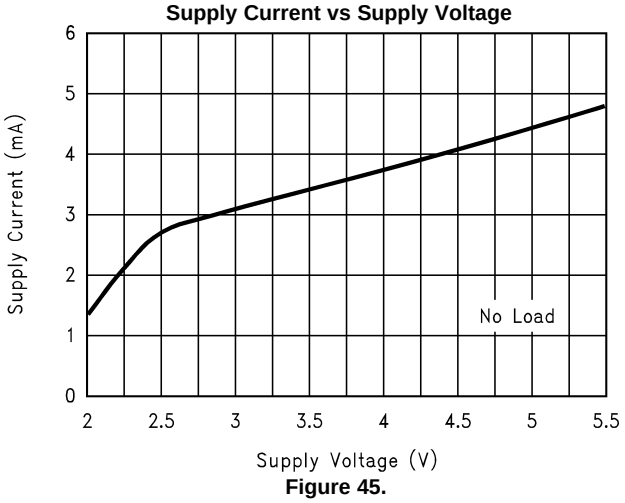


Figure 45.

Typical Performance Characteristics (continued)

Open Loop Frequency Response

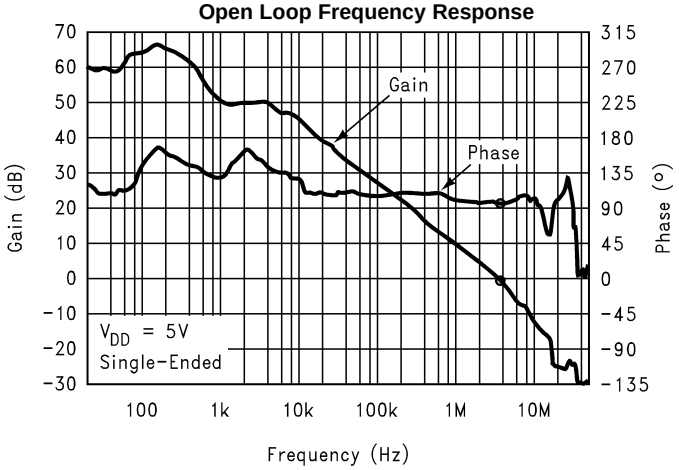
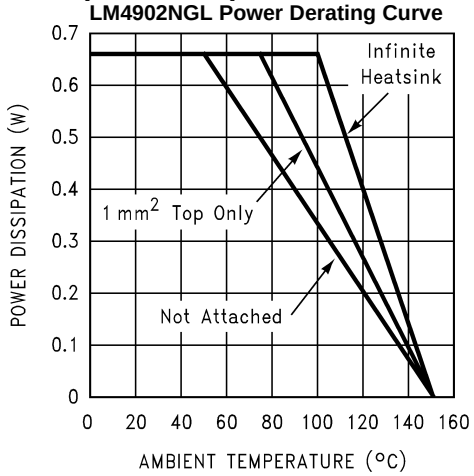


Figure 46.

LM4902NGL Power Derating Curve



This curve shows the LM4902NGL's thermal dissipation ability at different ambient temperatures given the exposed-DAP of the part is soldered to a plane of 1oz. Cu with an area given in the label of each curve.

Figure 47.

APPLICATION INFORMATION

EXPOSED-DAP PACKAGE PCB MOUNTING CONSIDERATION

The LM4902's exposed-DAP (die-attach paddle) package (NGL) provides a low thermal resistance between the die and the PCB to which the part is mounted and soldered. This allows rapid heat from the die to the surrounding PCB copper traces, ground plane, and surrounding air. This allows the LM4902NGL to operate at higher output power levels in higher ambient temperatures than the DGK package. Failing to optimize thermal design may compromise the high power performance and activate unwanted, though necessary, thermal shutdown protection.

The NGL package must have its DAP soldered to a copper pad on the PCB. The DAP's PCB copper pad is connected to a large plane of continuous unbroken copper. This plane forms a thermal mass, heat sink, and radiation area. Place the heat sink area on either outside plane in the case of a two-sided PCB, or on an inner layer of a board with more than two layers. Connect the DAP copper pad to the inner layer or backside copper heat sink area with 2 vias. The via diameter should be 0.012in - 0.013in with a 1.27mm pitch. Ensure efficient thermal conductivity by plating through the vias.

Best thermal performance is achieved with the largest practical heat sink area. The power derating curve in the Typical Performance Characteristics shows the maximum power dissipation versus temperature for several different areas of heat sink area. Placing the majority of the heat sink area on another plane is preferred as heat is best dissipated through the bottom of the chip. For further detailed and specific information concerning PCB layout, fabrication, and mounting an NGL (WSON) package, see the AN-1187 Application Report (Literature Number SNOA401).

BRIDGE CONFIGURATION EXPLANATION

As shown in *Figure 1*, the LM4902 has two operational amplifiers internally, allowing for a few different amplifier configurations. The first amplifier's gain is externally configurable, while the second amplifier is internally fixed in a unity-gain, inverting configuration. The closed-loop gain of the first amplifier is set by selecting the ratio of R_F to R_i while the second amplifier's gain is fixed by the two internal 20kΩ resistors. *Figure 1* shows that the output of amplifier one serves as the input to amplifier two which results in both amplifiers producing signals identical in magnitude, but out of phase 180°. Consequently, the differential gain for the IC is

$$A_{VD} = 2*(R_F/R_i) \quad (1)$$

By driving the load differentially through outputs V_{o1} and V_{o2}, an amplifier configuration commonly referred to as “bridged mode” is established. Bridged mode operation is different from the classical single-ended amplifier configuration where one side of its load is connected to ground.

A bridge amplifier design has a few distinct advantages over the single-ended configuration, as it provides differential drive to the load, thus doubling output swing for a specified supply voltage. Four times the output power is possible as compared to a single-ended amplifier under the same conditions. This increase in attainable output power assumes that the amplifier is not current limited or clipped. In order to choose an amplifier's closed-loop gain without causing excessive clipping, please refer to the AUDIO POWER AMPLIFIER DESIGN section.

A bridge configuration, such as the one used in LM4902, also creates a second advantage over single-ended amplifiers. Since the differential outputs, V_{o1} and V_{o2}, are biased at half-supply, no net DC voltage exists across the load. This eliminates the need for an output coupling capacitor which is required in a single supply, single-ended amplifier configuration. If an output coupling capacitor is not used in a single-ended configuration, the half-supply bias across the load would result in both increased internal IC power dissipation as well as permanent loudspeaker damage.

POWER DISSIPATION

Power dissipation is a major concern when designing a successful amplifier, whether the amplifier is bridged or single-ended. Equation 2 states the maximum power dissipation point for a bridge amplifier operating at a given supply voltage and driving a specified output load.

$$P_{DMAX} = (V_{DD})^2/(2\pi^2 R_L) \quad \text{Single-Ended} \quad (2)$$

However, a direct consequence of the increased power delivered to the load by a bridge amplifier is an increase in internal power dissipation point for a bridge amplifier operating at the same conditions.

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

Since the LM4902 has two operational amplifiers in one package, the maximum internal power dissipation is 4 times that of a single-ended amplifier. Even with this substantial increase in power dissipation, the LM4902 does not require heatsinking. From Equation 2, assuming a 5V power supply and an 8Ω load, the maximum power dissipation point is 625 mW. The maximum power dissipation point obtained from Equation 3 must not be greater than the power dissipation that results from Equation 4:

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

For package DGK, θ_{JA} = 190°C/W. T_{JMAX} = 150°C for the LM4902. Depending on the ambient temperature, T_A, of the system surroundings, Equation 4 can be used to find the maximum internal power dissipation supported by the IC packaging. If the result of Equation 3 is greater than that of Equation 4, then either the supply voltage must be decreased, the load impedance increased, the ambient temperature reduced, or the θ_{JA} reduced with heatsinking. In many cases larger traces near the output, V_{DD}, and Gnd pins can be used to lower the θ_{JA}. The larger areas of copper provide a form of heatsinking allowing a higher power dissipation. For the typical application of a 5V power supply, with an 8Ω load, the maximum ambient temperature possible without violating the maximum junction temperature is approximately 30°C provided that device operation is around the maximum power dissipation point. Internal power dissipation is a function of output power. If typical operation is not around the maximum power dissipation point, the ambient temperature can be increased. Refer to the Typical Performance Characteristics

POWER SUPPLY BYPASSING

As with any power amplifier, proper supply bypassing is critical for low noise performance and high power supply rejection. The capacitor location on both the bypass and power supply pins should be as close to the device as possible. The effect of a larger half supply bypass capacitor is improved PSRR due to increased half-supply stability. Typical applications employ a 5V regulator with 10µF and a 0.1µF bypass capacitors which aid in supply stability, but do not eliminate the need for bypassing the supply nodes of the LM4902. The selection of bypass capacitors, especially C_B, is thus dependent upon desired PSRR requirements, click and pop performance as explained in the section, PROPER SELECTION OF EXTERNAL COMPONENTS, system cost, and size constraints.

SHUTDOWN FUNCTION

In order to reduce power consumption while not in use, the LM4902 contains a shutdown pin to externally turn off the amplifier's bias circuitry. This shutdown feature turns the amplifier off when a logic low is placed on the shutdown pin. The trigger point between a logic low and logic high level is typically half supply. It is best to switch between ground and supply to provide maximum device performance. By switching the shutdown pin to GND, the LM4902 supply current draw will be minimized in idle mode. While the device will be disabled with shutdown pin voltages greater than GND, the idle current may be greater than the typical value of 0.1µA. In either case, the shutdown pin should be tied to a definite voltage to avoid unwanted state changes.

In many applications, a microcontroller or microprocessor output is used to control the shutdown circuitry which provides a quick, smooth transition into shutdown. Another solution is to use a single-pole, single-throw switch in conjunction with an external pull-up resistor. When the switch is closed, the shutdown pin is connected to ground and disables the amplifier. If the switch is open, then the external pull-up resistor will enable the LM4902. This scheme ensures that the shutdown pin will not float, thus preventing unwanted state changes.

PROPER SELECTION OF EXTERNAL COMPONENTS

Proper selection of external components in applications using integrated power amplifiers is critical to optimize device and system performance. While the LM4902 is tolerant to a variety of external component combinations, consideration to component values must be used to maximize overall system quality.

The LM4902 is unity-gain stable, giving a designer maximum system flexibility. The LM4902 should be used in low gain configurations to minimize THD+N values, and maximize the signal to noise ratio. Low gain configurations require large input signals to obtain a given output power. Input signals equal to or greater than 1 Vrms are available from sources such as audio codecs. Please refer to the section, AUDIO POWER AMPLIFIER DESIGN, for a more complete explanation of proper gain selection.

Besides gain, one of the major considerations is the closed-loop bandwidth of the amplifier. To a large extent, the bandwidth is dictated by the choice of external components shown in *Figure 1*. The input coupling capacitor, C_i, forms a first order high pass filter which limits low frequency response. This value should be chosen based on needed frequency response for a few distinct reasons.

Selection of Input Capacitor Size

Large input capacitors are both expensive and space hungry for portable designs. Clearly, a certain sized capacitor is needed to couple in low frequencies without severe attenuation. But in many cases the speakers used in portable systems, whether internal or external, have little ability to reproduce signals below 150Hz. In this case using a large input capacitor may not increase system performance.

In addition to system cost and size, click and pop performance is effected by the size of the input coupling capacitor, C_i. A larger input coupling capacitor requires more charge to reach its quiescent DC voltage (nominally ½ V_{DD}). This charge comes from the output via the feedback and is apt to create pops upon device enable. Thus, by minimizing the capacitor size based on necessary low frequency response, turn-on pops can be minimized.

Besides minimizing the input capacitor size, careful consideration should be paid to the bypass capacitor value. Bypass capacitor, C_B, is the most critical component to minimize turn-on pops since it determines how fast the LM4902 turns on. The slower the LM4902's outputs ramp to their quiescent DC voltage (nominally ½ V_{DD}), the smaller the turn-on pop. Choosing C_B equal to 1.0 µF along with a small value of C_i (in the range of 0.1µF to 0.39µF), should produce a clickless and popless shutdown function. While the device will function properly, (no oscillations or motorboating), with C_B equal to 0.1µF, the device will be much more susceptible to turn-on clicks and pops. Thus, a value of C_B equal to 1.0µF or larger is recommended in all but the most cost sensitive designs.

AUDIO POWER AMPLIFIER DESIGN

Design a 300 mW/8Ω Audio Amplifier

Given:

Power Output	300mWrms
Load Impedance	8Ω
Input Level	1Vrms
Input Impedance	20kΩ
Bandwidth	100Hz–20 kHz ± 0.25dB

A designer must first determine the minimum supply rail to obtain the specified output power. By extrapolating from the Output Power vs Supply Voltage graphs in the Typical Performance Characteristics section, the supply rail can be easily found. A second way to determine the minimum supply rail is to calculate the required V_{opeak} using Equation 5 and add the dropout voltage. Using this method, the minimum supply voltage would be (V_{opeak} + (2*V_{OD})), where V_{OD} is extrapolated from the Dropout Voltage vs Supply Voltage curve in the Typical Performance Characteristics section.

$$V_{opeak} = \sqrt{(2R_L P_O)} \tag{5}$$

Using the Output Power vs Supply Voltage graph for an 8Ω load, the minimum supply rail is 3.5V. But since 5V is a standard supply voltage in most applications, it is chosen for the supply rail. Extra supply voltage creates headroom that allows the LM4902 to reproduce peaks in excess of 700 mW without producing audible distortion. At this time, the designer must make sure that the power supply choice along with the output impedance does not violate the conditions explained in the POWER DISSIPATION section.

Once the power dissipation equations have been addressed, the required differential gain can be determined from Equation 6.

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

$$R_F/R_i = A_{VD}/2 \tag{7}$$

From Equation 6, the minimum A_{VD} is 1.55; use A_{VD} = 2.

Since the desired input impedance was 20 kΩ, and with a A_{VD} of 2, a ratio of 1:1 of R_F to R_i results in an allocation of R_i = R_F = 20 kΩ. The final design step is to address the bandwidth requirements which must be stated as a pair of −3 dB frequency points. Five times away from a pole gives 0.17 dB down from passband response which is better than the required ±0.25 dB specified.

$$f_L = 100Hz/5 = 20Hz \tag{8}$$

f_H = 20kHz × 5 = 100kHz (9)

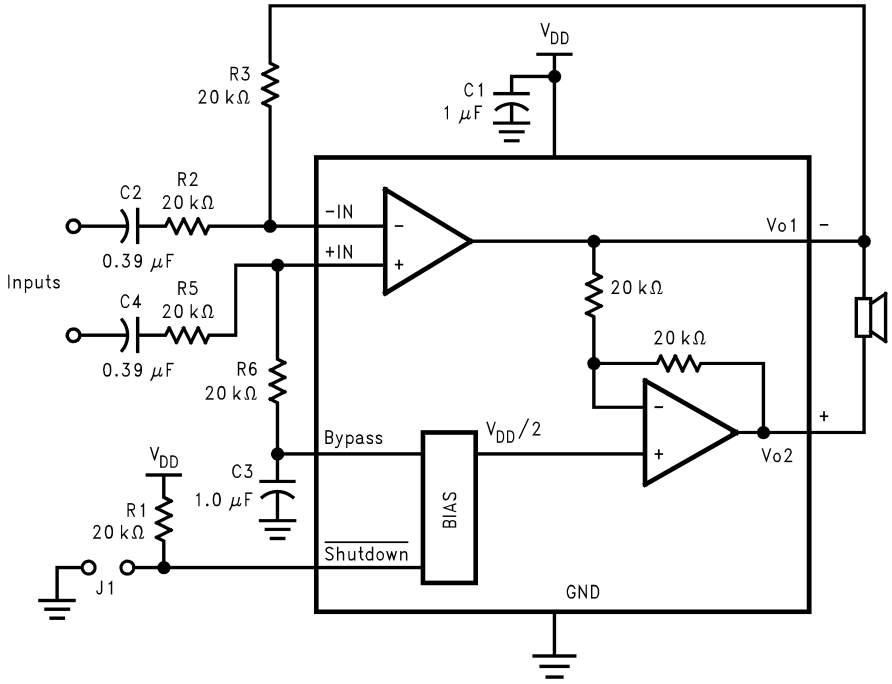
As stated in the External Components Description section, R_i in conjunction with C_i create a highpass filter.

$$C_i \geq \frac{1}{2\pi R_i f_c} \quad (10)$$

$C_i \geq 1/(2\pi * 20\ k\Omega * 20\ Hz) = 0.397\mu F$; use 0.39µF (11)

The high frequency pole is determined by the product of the desired high frequency pole, f_H, and the differential gain, A_{VD}. With a A_{VD} = 2 and f_H = 100kHz, the resulting GBWP = 100kHz which is much smaller than the LM4902 GBWP of 25MHz. This figure displays that if a designer has a need to design an amplifier with a higher differential gain, the LM4902 can still be used without running into bandwidth problems.

DIFFERENTIAL AMPLIFIER CONFIGURATION FOR LM4902



REVISION HISTORY

Changes from Revision C (May 2013) to Revision D **Page**

- Changed layout of National Data Sheet to TI format 18

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM4902MM/NOPB	ACTIVE	VSSOP	DGK	8	1000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	GC3	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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

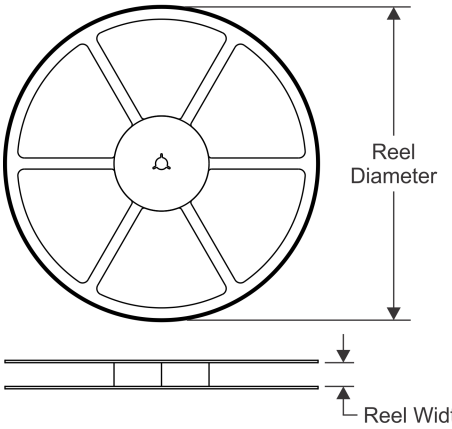
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

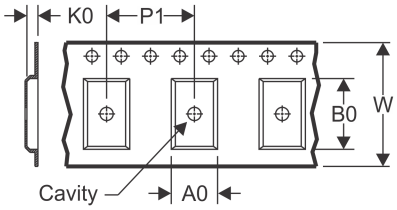
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

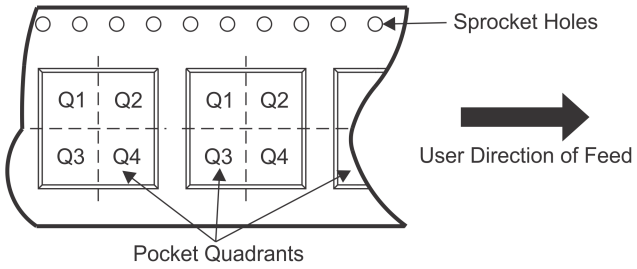


TAPE DIMENSIONS



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

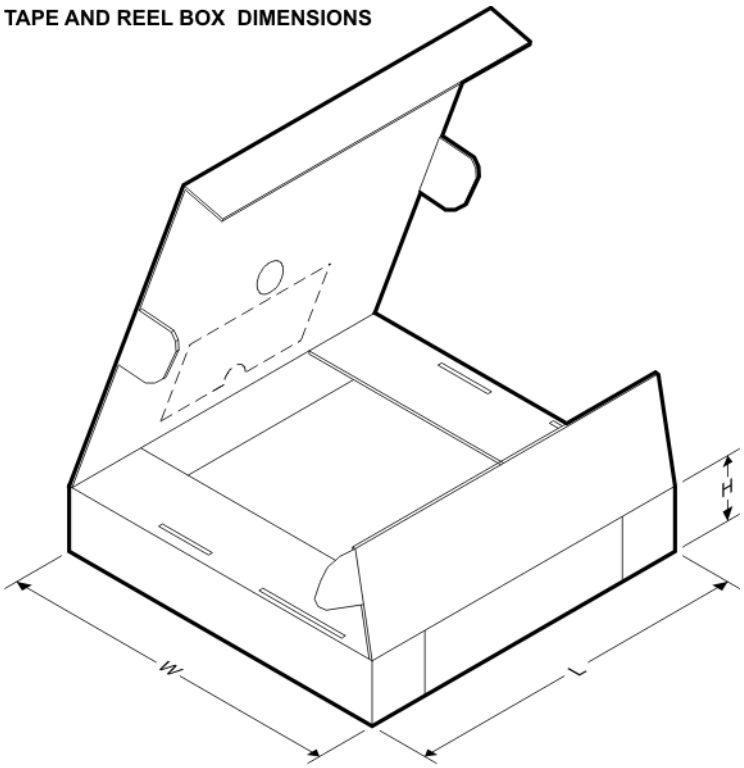
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
LM4902MM/NOPB	VSSOP	DGK	8	1000	178.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

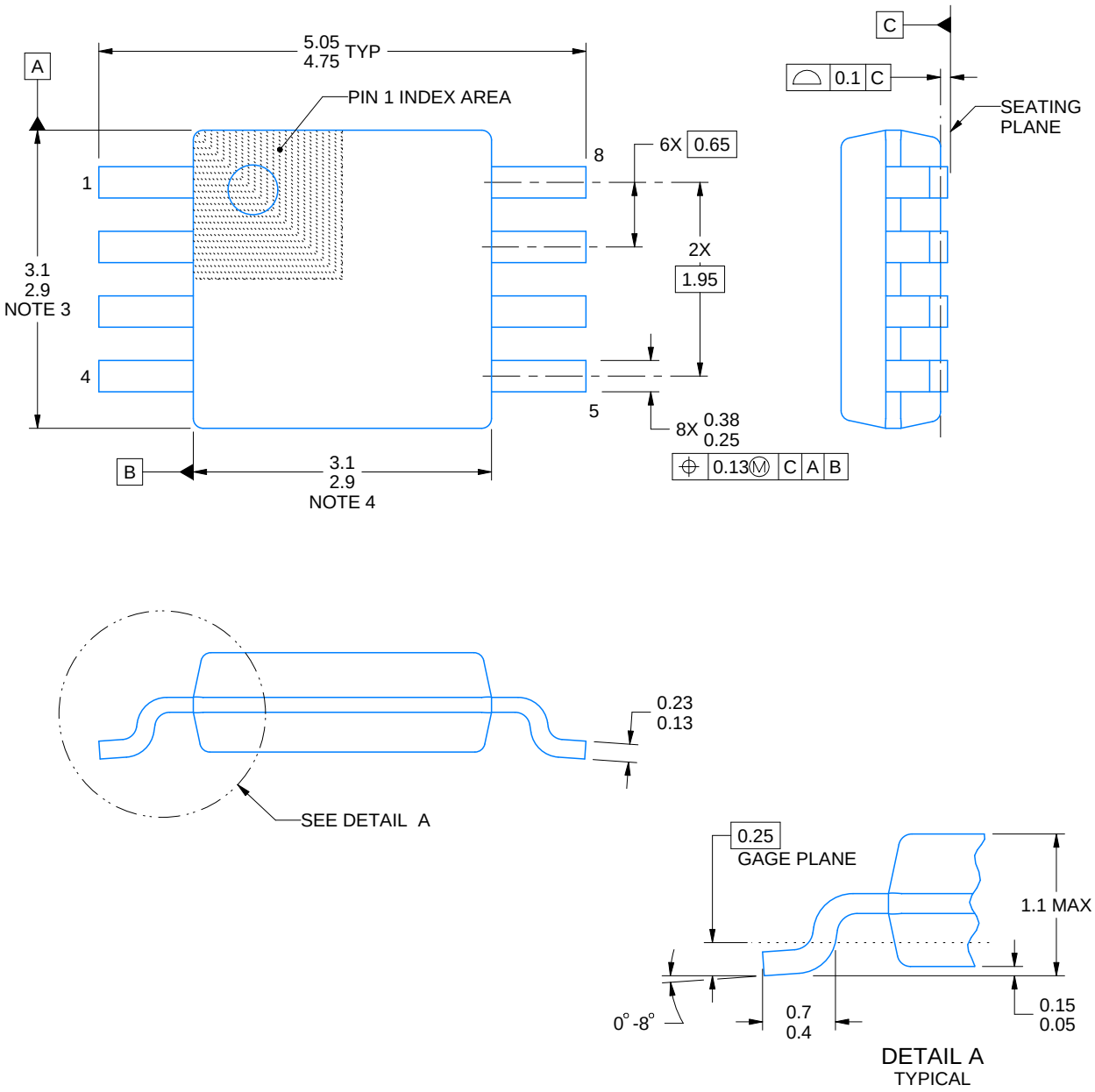
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM4902MM/NOPB	VSSOP	DGK	8	1000	208.0	191.0	35.0

PACKAGE OUTLINE

DGK0008A

VSSOP - 1.1 mm max height

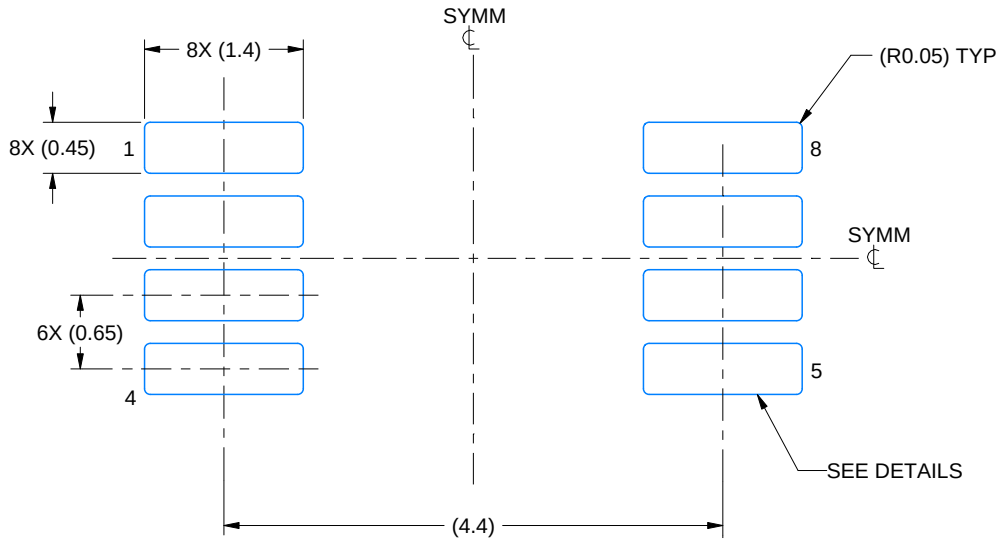
SMALL OUTLINE PACKAGE



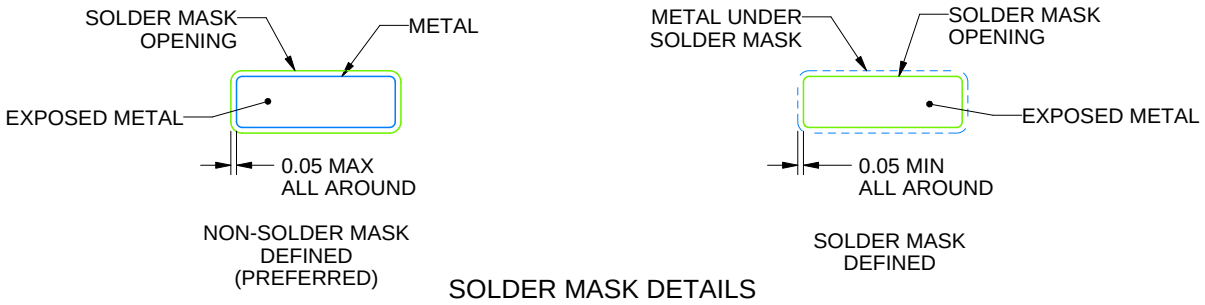
PowerPAD is a trademark of Texas Instruments.

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. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-187.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X

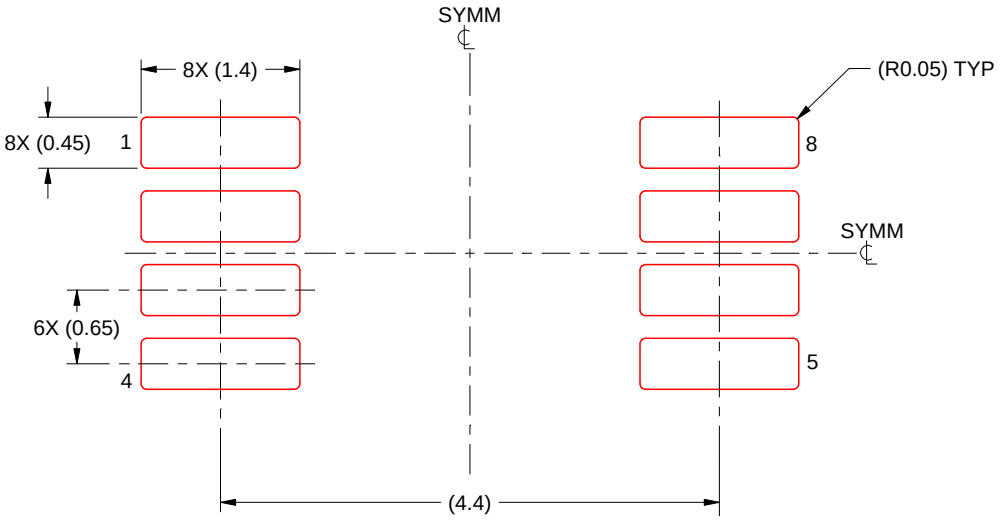


SOLDER MASK DETAILS

4214862/A 04/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. 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.
9. Size of metal pad may vary due to creepage requirement.



SOLDER PASTE EXAMPLE
SCALE: 15X

4214862/A 04/2023

NOTES: (continued)

11. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
12. Board assembly site may have different recommendations for stencil design.

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